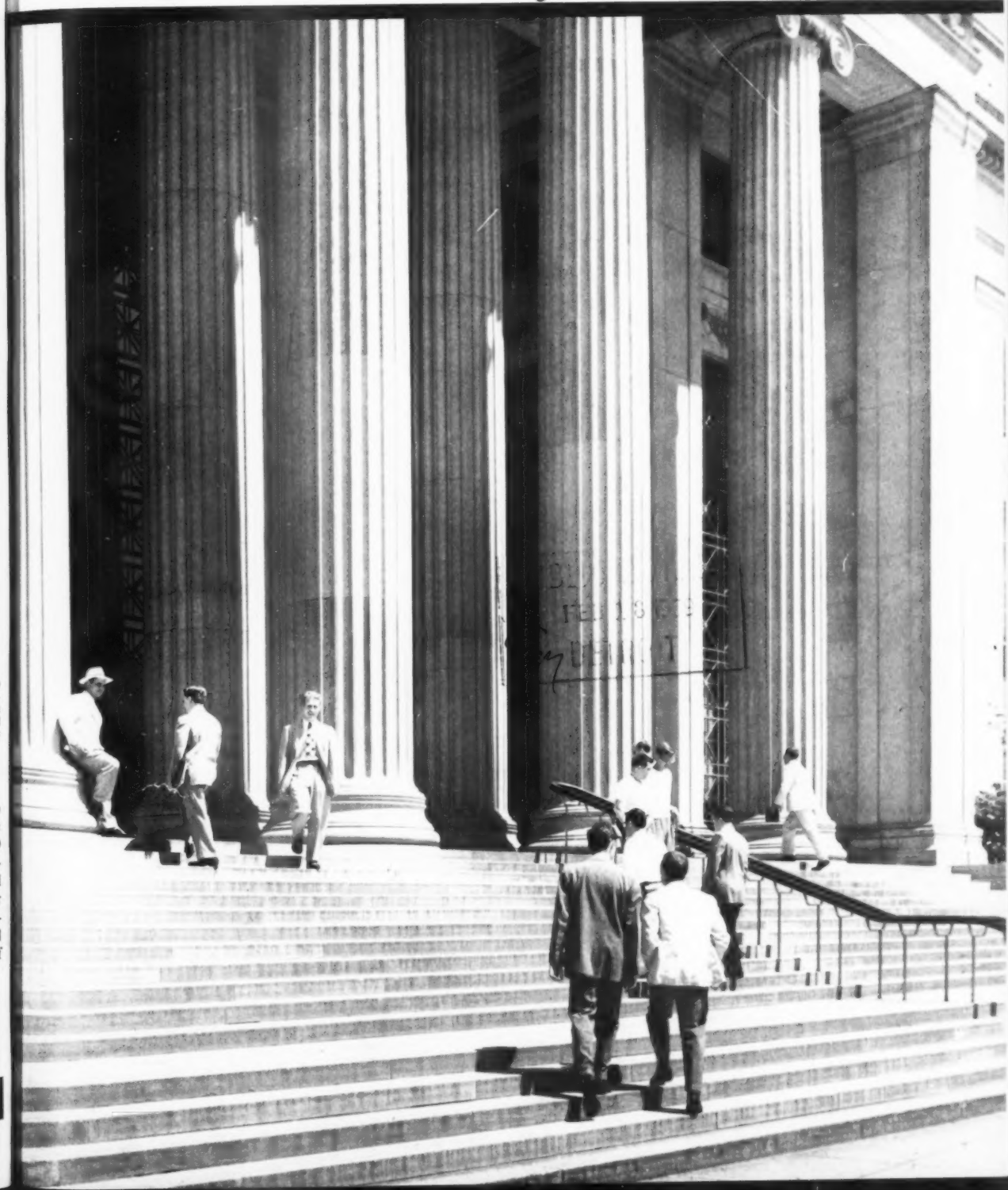
TECHNOLOGY DEPT

TECHNOLOGY REVIEW

February 1959

Vol 61 #4



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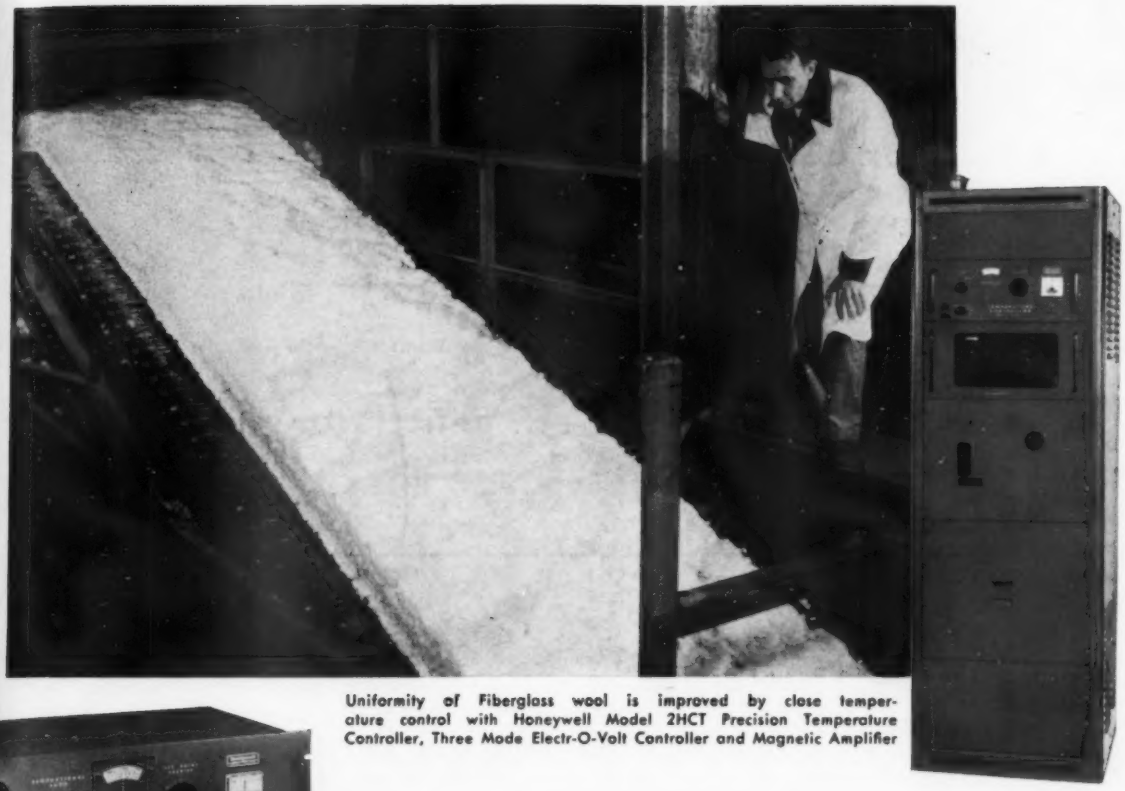

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Model 2HCT-2, single range control unit with direct reading analog dial, is available in a wide variety of ranges for any millivoltage or thermocouple input.

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There are 2 standard models: The 2HCT-2, which is shown above at left, and the 2HCT-3, which is designed for noble metal couples, covering temperatures from 0 to 3,000°F in 3 steps. Setting to ½ part in 3,000 is accomplished with a direct reading digital dial.

For applications requiring reset and derivative control functions, the 2HCT is used with a Honeywell Three Mode Electr-O-Volt Controller. Write for 2HCT Specification Sheet to Minneapolis-Honeywell, Dept. 1, Boston Division, 40 Life Street, Boston, Mass.

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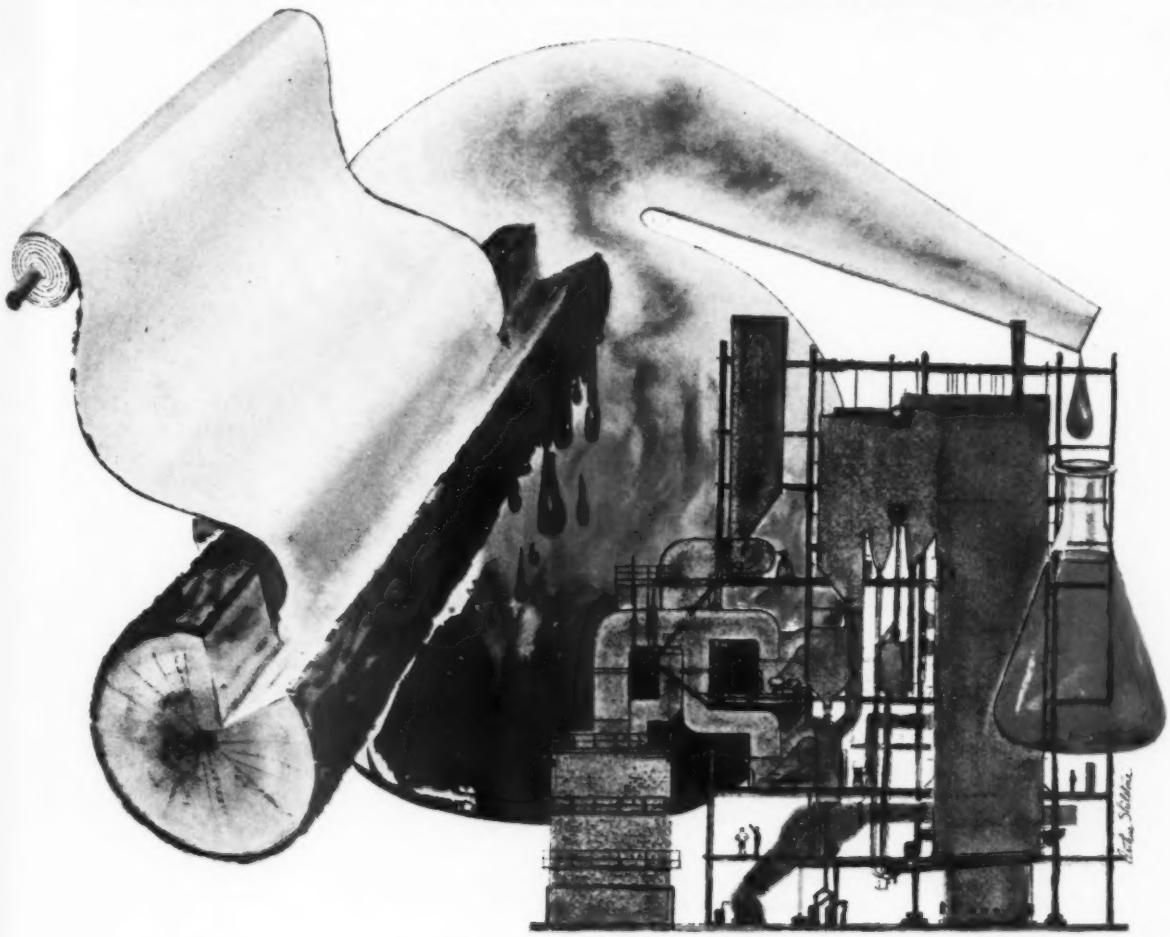
"CREATIVE ENGINEERING" REAPS A CHEMICAL HARVEST . . . BUILDS PULP-AND-PAPER PROFITS



World's largest chemical recovery unit achieves unprecedented economies in the pulp and paper industry

Chemical recovery is basic to the multi-billion-dollar pulp-and-paper industry. Valuable chemicals are salvaged from "black liquor," a residue of pulp manufacture. And the modern recovery process also produces large quantities of by-product steam.

Just a few years ago, the industry believed that recovery units had reached maximum size, with capacities (black liquor dry solids) of about 1,000,000 pounds per day. C-E engineers, aware that larger installations would mean lower investment and operating costs per unit of capacity, developed half a dozen major innovations in quick succession—and broke through the size barrier.

Twenty-five units of more than 1,000,000-pounds capacity have since been purchased from C-E by leading producers. The largest of these—a 2,000,000-pound unit—has now been in service for more than a year. Despite their high initial costs, such units usually pay for themselves in about two years.

This concern with a specific industry's capital problems—and deep involvement with that industry's technology—is characteristic of the C-E approach.

"CREATIVE ENGINEERING" is the foundation on which Combustion's leadership rests. The products which bear the C-E mark of leadership include:

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ENGINEERS—

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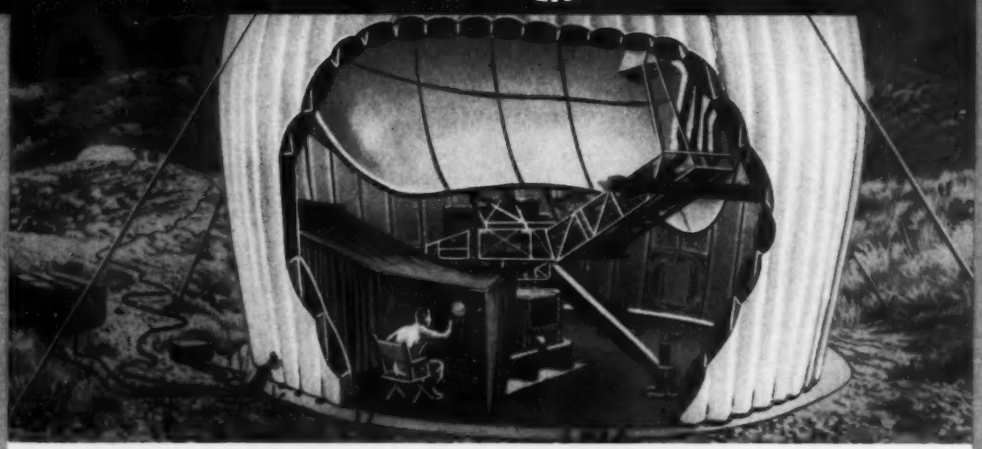

As fast on the move as a fighting Marine is the new "TEW" (tactical early warning) radar system being developed by Sperry for the Marine Corps. Only one-fourth the size and weight of conventional radars, TEW is easily carried to battle areas by helicopter, cargo plane, truck or amphibious vehicle. Within two hours, an 18-man crew can erect the TEW system and place it in operation.

With its very long range and portable construction, TEW provides the Marines with the means to extend the nation's defense perimeter and insure added protection for key installations and outposts.

If you're interested, not in an engineering job, but in an engineering CAREER, check Sperry—

Sperry Gyroscope also stands for steady growth. Not just for the company—but for its engineers. Sperry engineers are career engineers, working on projects—like TEW—that are creative, interesting, important. They stay, and grow, with us. That's why over 2,600 Sperry employees are 15-year men. And—today we're expanding, diversifying more than ever. If engineering is your life's work—check Sperry.

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Research is a living thing to the people of Union Carbide—for it is the foundation upon which their work is built. They have created hundreds of useful products from such basic substances as oil, natural gas, ores, air, and water. And the wonders yet to come, the completely new things of tomorrow, are being sought and found in Union Carbide's laboratories today.

Learn about the exciting work going on now in alloys, carbons, chemicals, gases, plastics, and nuclear energy. Write for "Products and Processes" Booklet A, Union Carbide Corporation, 30 East 42nd St., New York 17, N.Y. In Canada, Union Carbide Canada Limited, Toronto.

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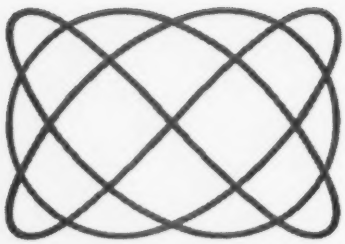
...a hand in things to come



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are invited to join the Lincoln Laboratory scientists and engineers whose ideas have contributed to new concepts in the field of electronic air defense.

A brochure describing the following Laboratory programs will be forwarded upon request.

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THE TABULAR VIEW

Thorough Endorsement. — According to gossip that reached the "land of the bean and the cod," New Mexico's Regional Conference was everywhere given the nod. Selected because of its interest, in every conceivable way, is the paper entitled "The Challenge," delivered by JAMES W. MCRAE. It tells of achievements of science, and progress that should make man soar. But it notes with an air of discouragement that these are used mainly for war. "The Challenge" proposes that science – and man's engineering feats, too – be turned into purposes peaceful, and that they make warfare taboo.

Dr. McRae, author of "The Challenge" (page 191) is a native of Vancouver and received the B.S. degree in electrical engineering from the University of British Columbia in 1933. He received the M.S. degree a year later and the Ph.D. degree in 1937, both from California Institute of Technology. His engineering and administrative work has been entirely in the field of electrical communications and, except for military service as an officer during World War II, he has been affiliated with the Bell System. Early in 1942, he accepted a commission as Major in the U.S. Army Signal Corps and was assigned to the Chief Signal Officer in Washington. Two years later, he became chief of the Engineering Staff at the Signal Corps Engineering Laboratories at Bradley Beach, N.J., and attained the rank of Colonel before returning to civilian life. As a member of the technical staff of the Bell Telephone Laboratories, he was engaged in research on transoceanic and microwave communication and gradually turned to administrative work. In 1949 he became director of Transmission Development, and in 1951 was elected vice-president of Bell Telephone Laboratories. He became vice-president of Western Electric Company, and president of Sandia Corporation in 1953, and vice-president of the American Telephone and Telegraph Company in 1958. He has been active, and has held numerous important posts, in the Institute of Radio Engineers.

Helpful Nudge. — Tuition, transportation, and living costs are steadily rising, and college enrollment increases faster than new facilities can be built to accommodate students. Strangely enough, while students are competing with one another to get into college, the institutions of higher learning compete with one another for students. In contrast with past years, today's students make application to several colleges and frequently their final selection is based with an eye to economic factors. The status of present college admissions problems is outlined (page 195) by B. ALDEN THRESHER, '20, Professor of Economics and also Director of Admissions at M.I.T. Professor Thresher received the S.B. degree from M.I.T. in 1920 and the M.A. degree from Harvard University in 1928. From 1920 to 1925, he was assistant plant manager of the Eddystone Manufacturing Company, and from 1925 to 1927 was on the staff of the research

(Concluded on page 176)

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- Ultrasonic inspection

To keep pace with the steadily growing importance of the nuclear power field, Phelps Dodge will soon open one of the largest tube mills in the world at South Brunswick, N. J. This mill will have the most modern automatic tube fabricating machinery, the finest research laboratories and the most advanced testing equipment.

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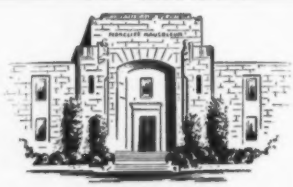
THE TABULAR VIEW

(Concluded from page 174)

division of the Dennison Manufacturing Company. He returned to M.I.T. in 1929 as an instructor in economics, was appointed assistant professor in 1932, and associate professor in 1935. In 1945 he was made professor of economics. He became Director of Admissions in 1936, and still holds that important Institute post. He is currently chairman of the College Entrance Examination Board.

Everyone's Dentist. — Once an object of frightening apprehension, the dentist chair has lost much of its former terror. In fact, such remarkable progress has been achieved in dental techniques, and so many new materials and improved methods have been introduced that everyone is encouraged to visit his dentist periodically. Such visits are all the more necessary for, by and large, as is recorded on page 199, the teeth of American citizens are in somewhat poor repair. The author of "A Tooth for a Tooth" is FREDERIC W. NORDSIEK, '31, Editorial Associate of The Review since 1944, and well known to Review readers from more than 100 feature articles and unsigned Trend of Affairs items which have appeared in The Review consistently in the past 15 years. A native of New York, Mr. Nordsiek received the S.B. degree in Biology and Public Health from M.I.T. in 1931. He has had wide experience in research and administration in the food industry and in public health. From 1943 to 1951, he was assistant director, Research Service Department of Standard Brands, Inc. Since 1951, he has been associated with the American Cancer Society, where his present work deals with administering research grants and programs. Currently, Mr. Nordsiek is supplementing an already busy schedule with graduate studies in New York. He is a prolific and accurate writer and his articles on technical and nontechnical subjects have appeared in many publications.

Ferncliff Mausoleum,
Hartsdale, N.Y.
Gregory Webb, Architect



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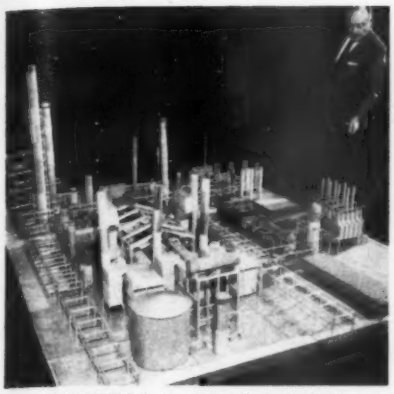
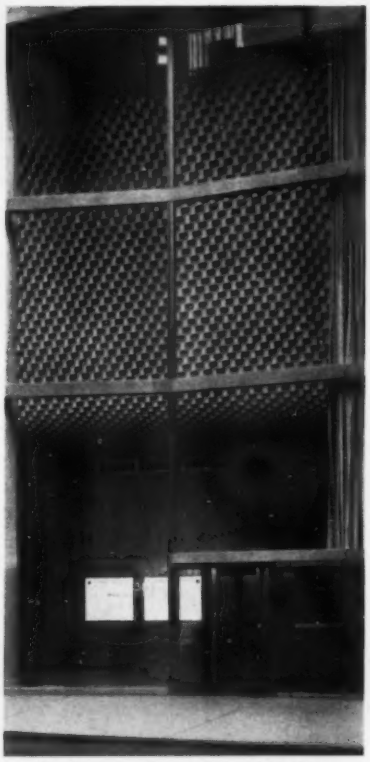
One of a series of advertisements on Lummus' world-wide facilities.



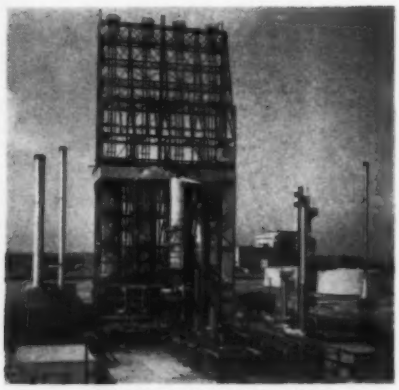
200,000,000 lb. per year ethylene plant



The Lummus Company headquarters
385 Madison Avenue, New York, N. Y.

Beryllium plant

High pressure acetylene chemicals plant



600 ton per day coking unit

Lummus New York is headquarters for design, engineering and construction

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The Lummus Company headquarters are at the business crossroads of the world in New York, ready to coordinate the engineering skills of over 3,000 permanent employees located in seven branch offices and subsidiaries throughout the world.

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In addition, Lummus maintains a 150,000 square foot Engineering Development Center in Newark, N. J., to bridge the practical gap between laboratory research findings and commercial plant operation. The Center has extensive pilot plant facilities in operation, and is equipped for designing and building new units.

Several recent domestic projects of The Lummus Company (pictured above) are: a 200,000,000 lb. per year ethylene plant; America's first full scale, high-pressure acetylene chemicals plant; a beryllium metal plant; and a 600 ton per day coking unit designed for the heaviest charge ever fed to a coker.

See Lummus on your next project.

Branch offices of The Lummus Company are located at Washington, D. C. and Houston, Texas.

Subsidiaries are in Montreal, Maracaibo, London, Paris, The Hague.

LUMMUS

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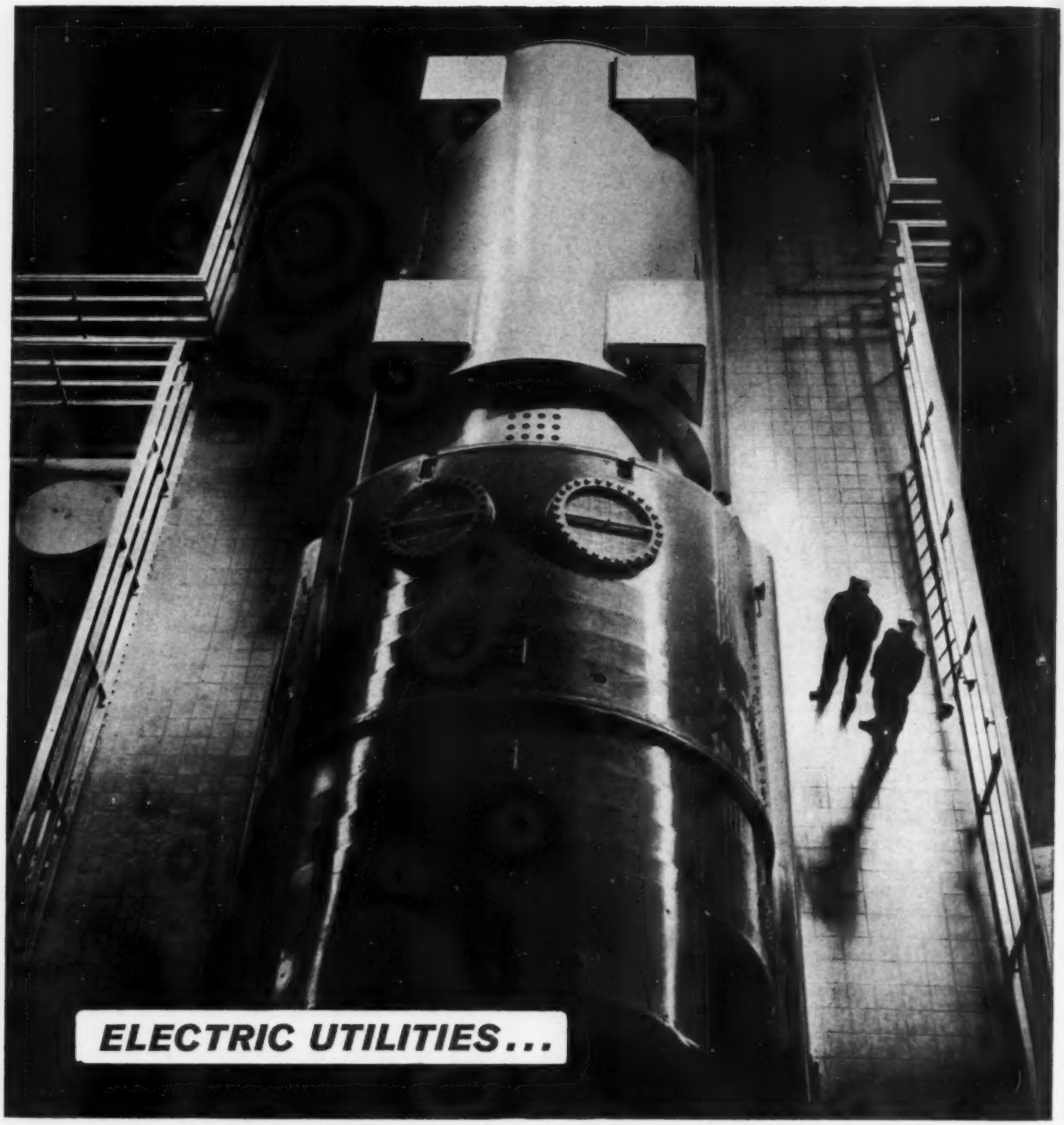

Where the Engineer Designs His Own Career

Here's an industry that started big after the war . . . surged ahead in every direction . . . keeps on growing today when others are tapering off . . . and still has its biggest years ahead. The electric utilities business is basically an engineering business. Many of its top executives come from engineering ranks; from systems planning, design, operations, research, or sales; and with backgrounds ranging from electronics and nucleonics to older branches of scientific learning. If you want a career in an *expanding* industry that is based on engineering look to our electric public utilities. We know you'll like working with them. We have been doing it for many years in supplying this great industry with Kerite quality insulated wire and cable. See your placement officer, or write us at 30 Church Street, New York 7, N. Y.

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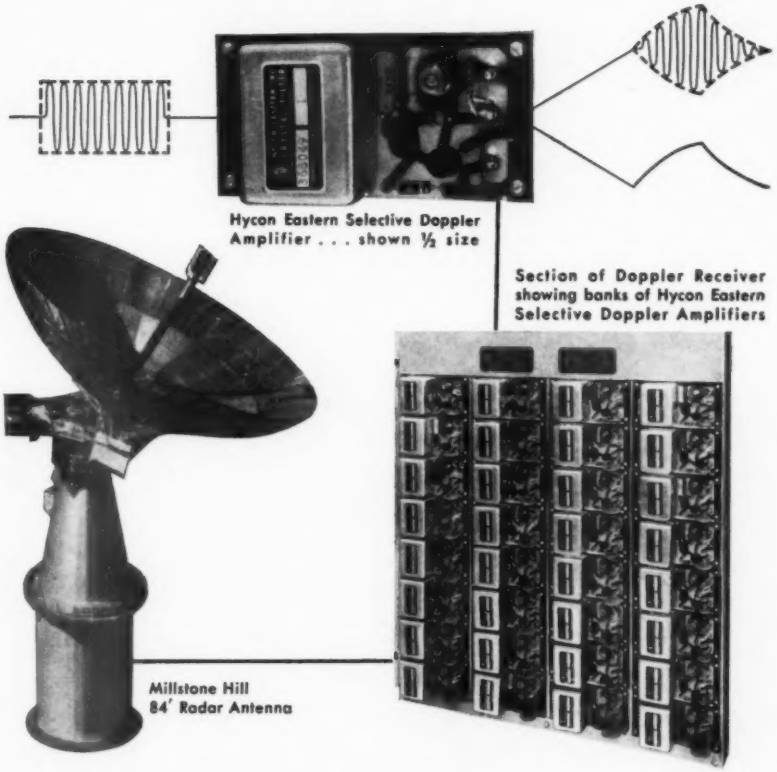


Hycon Eastern Selective Doppler Amplifier . . . shown ½ size

Section of Doppler Receiver showing banks of Hycon Eastern Selective Doppler Amplifiers

Millstone Hill 84′ Radar Antenna

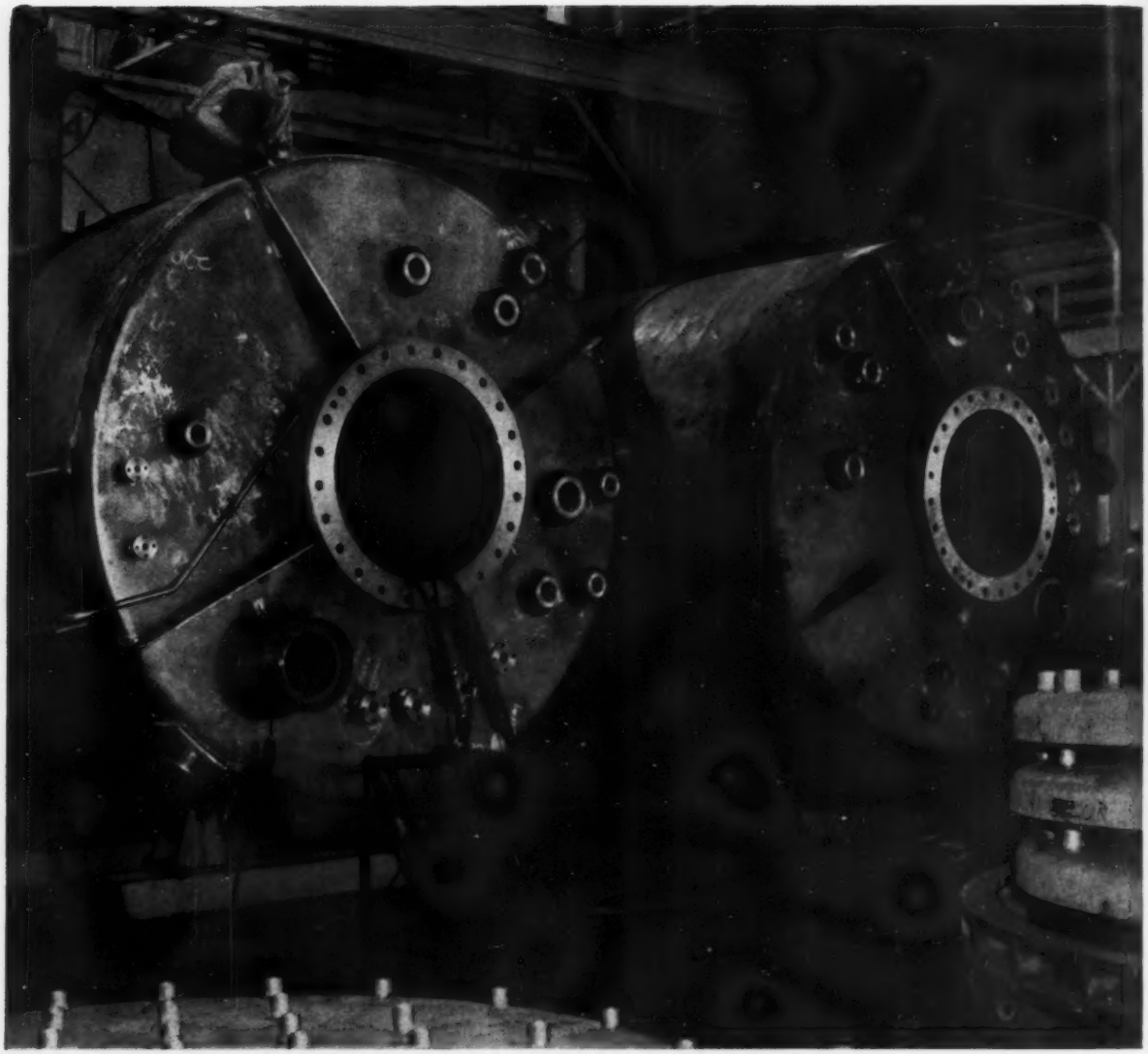
The problems in long range radar for today's ballistic missile defense systems require solutions that are unique yet reliable. Meeting these criteria is the Lincoln Laboratory's "Millstone Hill System". Working closely with Lincoln Laboratory on the transient response problems, Hycon Eastern provided "comb set" crystal filters and associated circuitry forming complete networks termed Selective Doppler Amplifiers.

Hycon Eastern offers a unique customer service by assuming total responsibility for exact pulse output. All crystal filters are tested and aligned under simulated operating conditions, using a pulsed input. Transistor amplification, active impedance transformation, and detector circuitry are provided for complete compatibility with the total system. These integrated units are delivered ready for immediate use.

Hycon Eastern is presently supplying crystal filter banks for airborne intercept, bomber defense, shipborne and land based detection and tracking systems. Write for Crystal Filter Bulletin.

HYCON EASTERN, INC.

75 Cambridge Parkway Dept. H Cambridge 42, Mass.



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Ever since work on atomic reactors began, Graver has been building stainless tanks for transferring radioactive process effluents. Filled by remote control and cooled to remove heat from radioactive decay, tanks of the design shown above have been in service long enough to now be regarded as a standard for this use.

Stainless is useful for its ability to withstand either basic or acidic liquid wastes for a long time without serious corrosion. For mixed radioactive wastes with many "half-lives", such tanks may be required to hold dangerous isotopes for a very long time. The craftsmanship must be of the highest, which is never a question with Graver's hundred-year reputation for quality fabrication. For atomic energy use or for industrial wastes, stainless and alloy fabrication by Graver provides the complete answer for long-lived installations.

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THE TECHNOLOGY REVIEW

EDITED AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

CONTENTS for FEBRUARY, 1959, Vol. 61, No. 4

STEPS TOWARD KNOWLEDGE — Front Cover
Photograph by M.I.T. Photographic Service

DYNAMIC BURST — Frontispiece 182
Photograph by Harold E. Edgerton

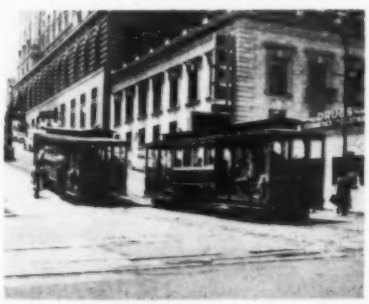
THE CHALLENGE — By James W. McRae 191
Regional Conference address stresses the large-scale active and aggressive application of science and technology for promoting peace, as man's next great challenge

THE PROBLEMS OF COLLEGE ADMISSIONS — I — By B. Alden Thresher 195
The Admissions Office, as well as the student applicants, faces mounting problems as rising costs and increasing competition influence admissions into colleges

A TOOTH FOR A TOOTH — By Frederic W. Nordsiek 199
The rapid advances in dental techniques and the training of an increasing number of dentists bode well for man who has left good teeth behind in his evolutionary climb

THE TABULAR VIEW — 174
Contributors and contributions to this issue

THE TREND OF AFFAIRS — 183
Relating to the Massachusetts Institute of Technology



Uphill Going!

The world renowned and warmly cherished cable cars of San Francisco retain their popularity, as passenger rail service generally declines.

Photograph by Ward Allan Howe

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Dynamic Burst

This halftone reproduction is an interesting example of the limits to which photographic techniques can be pushed to aid man's study of nature. It shows the ejection of high-speed particles coming from the end of a No. 6 Du Pont dynamite cap photographed about 35 microseconds after detonation. The particles have average velocities of about 6,000 feet per second, although a few particles may reach velocities of about 10,000 feet per second. White spots are caused by impact of fragments from the dynamite cap case striking a plate of safety glass.

Images of particles traveling at such high speeds would be completely blurred unless the exposure time were of very short duration. In the example shown here, exposure time was about one ten-millionth of a second.

This illustration was produced by Harold E. Edgerton, '27, Professor of Electrical Measurements, who is internationally known for his work in developing illuminants, shutters, cameras, and related apparatus for increasing the effectiveness of photography as an analytical tool and important implement of science.

The Technology Review

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The Trend of Affairs

Aeronautics and Astronautics

■ Astronautics has officially become a part of the curriculum at the Institute. The name of the Department of Aeronautical Engineering has been changed to Department of Aeronautics and Astronautics, C. Richard Soderberg, '20, Dean of the School of Engineering, announced recently. Charles S. Draper, '26, will continue to head the Department, which is regarded as one of the most outstanding in the world. Regarding the change, Dr. Draper said:

In recent years, as the potentialities of rockets and other spacecraft have become plainer, the Department has been increasingly concerned with space.

The airplane is here to stay for a long time, and we will continue to regard aeronautics as fundamental. But the sky, or speaking more precisely, the air, is no longer the limit. Interplanetary travel is yet to be accomplished but clearly it will be feasible.

M.I.T. must educate men who are prepared not only to design and build the craft that we conceive of today but to engineer new types of flight vehicles which at this time we can only imagine.

The problems of aerodynamics, structures, propulsion and control associated with aeronautics and astronautics differ in detail but are so much alike in basic principles that aeronautical engineering and astronautical engineering form a single field. This field surely contains some of the greatest challenges to science and engineering that now confront the human race. For those individuals who are motivated by these challenges and have the talents and fortitude for a rigorous education, aeronautics and astronautics have much to offer.

To meet current needs, aeronautical and astronautical engineering must deal with the problems of flight vehicles ranging from helicopters, vertical take-off convertiplanes, short take-off and landing craft, subsonic aircraft, supersonic aircraft and guided missiles moving within the atmosphere, to ballistic missiles, satellites, lunar vehicles, and interplanetary craft.

Education in science and applied science to provide the background required for this range of vehicles must be thorough in all fundamentals and carefully planned so as to be effective.

M.I.T. pioneered in aeronautics and in recent years has also pioneered in astronautics. As early as 1896, a wind tunnel was built at the Institute for the study of wind pressures. It produced winds of 20 miles an hour. The hypersonic wind tunnel of the Naval Supersonic Laboratory now at M.I.T. is capable of airflows at Mach 8 (about 3,100 miles per hour at 2,000 degrees).

Various studies in aeronautics were made, and students experimented with gliders in the early years after the Wright Brothers made their first flight. Lectures were presented from time to time and in 1913 the first formal Course in Aeronautical Engineering was offered at the Institute – perhaps the first in the United States.

Jerome C. Hunsaker, '12, who graduated from Annapolis (No. 1 in his class) and came to M.I.T. in 1909 as a graduate student in naval architecture, decided to make aeronautics a career. After receiving a master's degree in 1912, he was sent by the Navy to Europe to learn what was being done in aeronautics there and, upon returning to M.I.T., gave the new graduate Course in Aeronautical Engineering. He directed the construction of a wind tunnel in 1914, one of the first large ones in the United States.

Meanwhile he continued as a graduate student, and in 1916 was awarded a doctor's degree for his work in the field of aeronautics, the first such degree at M.I.T.

Dr. Hunsaker returned to the Navy during World War I as chief of the newly constituted Aircraft Division of the Bureau of Construction and Repair. He designed the "NC" airplanes, one of which in 1919 made the first transatlantic flight, and designed the *Shenandoah*, the first zeppelin-type airship to use helium.

The first four-year undergraduate Course in Aeronautical Engineering at M.I.T. was started in 1926 by the late Edward P. Warner, '17. In 1932 Dr. Hunsaker returned to M.I.T. to take charge of it as well as the Department of Mechanical Engineering. Dr. Hunsaker served as the head of the Department of Aeronautical Engineering until 1951, when he was succeeded by Dr. Draper. An emeritus professor, Dr. Hunsaker is still active in the Department.

Dr. Draper had received a master's degree in Aeronautical Engineering in 1928 and began teaching the following year. Although his interest in aeronautics has been broad, his special field has been instrumentation. He is regarded as the American father of inertial guidance, the system which makes it possible to navigate rockets, space vehicles, and submarines without use of radio or magnetic compass.

Dr. Draper's conception of the use of gyroscopes in inertial guidance and gunsights dates to the early 1930's. He is director of the M.I.T. Instrumentation Laboratory, in which a staff of 900 work on these problems. Among other accomplishments, the laboratory has developed the inertial guidance system for *Polaris,* the Navy ballistic missile designed for launching from submarines.

One of the earliest courses in inertial guidance was given at M.I.T. Astronautical subjects were first presented 10 years ago, and sponsored research in many fields has served to keep teaching at the very frontier of this rapidly developing field concerned with long-range rockets and space vehicles.

The Department has been especially noted for research and teaching in such subjects as aeroelasticity, aircraft structures, stability, control, and automatic flight control. More than 50 subjects are now offered to students in the Department. These include not only advanced techniques now in use but also the principles of those likely to play a part in the astronautics of the future, such as nuclear power and ion propulsion.

Alumni of M.I.T. have been prominent in many branches of aeronautics. These include two who are now members of the M.I.T. Corporation – Donald W. Douglas, '14, and James H. Doolittle, '24.

Individuals Noteworthy

■ Important in early 1959 news were the 20 promotions, elections, or appointments presented below:

Alfred P. Sloan, Jr., '95, as a member of the National Council of the National Planning Association . . . *Clayton D. Grover, '22,* as Chief Officer, Whitehead Metals, Inc. . . . *John W. Beretta, '23,* as Chairman of the Texas State Board of Registration for Professional Engineers, and as a member, Board of Governors, Southwest Research Institute;

Harold C. Pearson, '23, as President, Construction Chemicals, Ltd., Ontario distributor for Dewey and Almy Chemical Division, W. R. Grace and Company of Canada, Ltd. . . . *William E. P. Doelger, '26,* as a trustee, Manhattan Savings Bank . . . *James R. Killian, Jr., '26,* as Chairman, Federal Council for Science and Technology, new government committee created to establish long-range policy for government support of scientific research and development;

Arthur R. Elliott, '28, as Vice-president and General Manager, Greater Winnipeg Gas Company, Manitoba . . . *Walter F. H. Mattlage, '28,* as General Manager, Fabrics and Finishes Department, E. I. du Pont de Nemours and Company, Inc. . . . *Edward M. Tittmann, '29,* as Vice-president and Director, American Smelting and Refining Company;

James B. Fisk, '31, as President, Bell Telephone Laboratories . . . *Daniel D. Strohmeier, '34,* and *William R. Hewlett, '36,* as trustees, respectively, of Webb Institute of Naval Architecture and of Mills College;

Adolph L. Antonio, '37, as Vice-president, Chemical Division, Aerojet-General Corporation – a subsidiary of General Tire and Rubber Company . . . *W. Gardner Barker, '37,* as President and Chief Executive Officer, Thomas J. Lipton, Inc. . . . *Jerry McAfee, '40,* as Vice-president of American Institute of Chemical Engineers for 1959;

Albert H. Bowker, '41, as Dean, Graduate Division, Stanford University . . . *Rogers B. Finch, '41,* as Associate Dean, School of Science, Rensselaer Polytechnic Institute . . . *Stanley N. Golembe, '42,* as President, Power Sources, Inc., Burlington, Mass.;

David K. Hardin, '49, as Executive Vice-president, Market Facts, Inc., Chicago . . . *Renato N. Nicola, '53,* as President, Newton Company, Manchester, Conn.

■ Special honors recently awarded or announced to six Alumni include:

To *Harold S. Osborne, '08,* a special award "in appreciation of leadership," by the Engineers Joint Council . . . to *Thomas D'A. Brophy, '16,* Silver Stein Award "for outstanding service not only to M.I.T. and the Club but to charitable and civic affairs," by the M.I.T. Club of New York . . . to *Otto E. Kirchner, '24,* an award for "distinguished service in achieving safer utilization of aircraft," by the Flight Safety Foundation . . .

To *Thomas A. Knowles, '27,* a certificate of achievement "for significant contributions to the Army Missile Program," by the Army Ordnance Missile Command . . . to *Donald G. Fink, '33,* a technological award for "outstanding contribution by a scientist in industry toward improving technological training standards," by the New York Institute of Technology . . . to *Arthur B. Metzner, '51,* the 1958 Junior Award, by the American Institute of Chemical Engineers, for a paper (written with *George L. Houghton* and *Robert D. Vaughn*) entitled "For Heat Transfer in Non-Newtonian Fluids."

Hand in Hand

■ Co-operative engineering education in the United States, in which the vast facilities of American industry were linked with the best of college education to produce engineers with practical, as well as theoretical training, had its beginning in the United States around 1908. The half-century mark of this happy union of education and industry has been marked by the publication of *Hand in Hand,*• the first book to tell what this revolutionary co-operative movement can mean to high school students interested in science and engineering, to their parents, and to industry.

The 340-page book is dedicated to William H. Timbie, Professor of Electrical Engineering and Industrial Practice, Emeritus, who for many years was in charge of the M.I.T. Co-operative Course in Electrical Engineering.

The volume has been produced by a distinguished committee of engineers and educators. Alfred L. Dowden, '31, served as editor-and-chairman, and Eugene W. Boehne, '28, Professor of Electrical Engineering, as adviser. Professor Boehne succeeded Professor Timbie, and is administrator of the M.I.T. Co-operative Course in Electrical Engineering.

Biographical sketches and portrait illustrations of graduates from Course VI-A are a major part of this unusual volume.

• Medford, Mass.: Gordon and Company, 1958.

James L. Tryon: 1864–1958

■ James L. Tryon, Professor Emeritus of International Law and former Director of Admissions for M.I.T., died at the Lawrence Memorial Hospital on December 22. Dr. Tryon served the Institute for 17 years before his retirement in 1936, and will be remembered by the hundreds of students to whom he was an adviser and friend.

Born in Boston in 1864, Dr. Tryon worked on Portland, Maine, newspapers during his youth. He was graduated from Harvard College in 1894 and then received a degree of bachelor of divinity from the Episcopal Theological School of Massachusetts. After serving for 10 years as rector of the All Saints' Church in Attleboro, and of the Church of St. John the Evangelist in Mansfield, he turned to law, attended Boston University, and received the degrees of bachelor of laws in 1909 and doctor of philosophy in 1910.

A dedicated worker for world peace, Dr. Tryon held a secretarial position with the New England branch of the American Peace Society and was director of the Massachusetts and Maine Peace Societies. He attended international peace congresses in Munich, London, Geneva, The Hague, and Constance, Germany, before World War I, and lectured on peace in many American and Canadian churches and universities. Following the war he lectured on international law at the Episcopal Theological School in Cambridge and the University of Maine before coming to M.I.T. in 1920 as an instructor in history. He became director of admissions in 1930. He was a member of the Maine bar, the American Society of International Law, the International Law Association, the American Society for Engineering Education, the Field and Forest Club, and the Masons.

Dr. Tryon is survived by: a son, Richard W. Tryon of Springfield, N.J.; a daughter, Miss Sylvia Tryon of Medford; a sister, Dr. Geneva Tryon of Cape Elizabeth, Maine; three grandchildren; and three great grandchildren. His wife, Mrs. Katherine Allen Tryon, a pioneer lecturer on ornithology and an accomplished artist, died in 1952.

Sophomore Wins Model Car Competition

■ An 18-year-old native of Philadelphia, Pa., now a student at M.I.T., has won honors in the nationwide model car competition which was conducted by Fisher Body Craftsman's Guild.

Thomas L. DeFazio, '61, who lives at 2731 South 12th Street, Philadelphia, won the senior division first place state award for Pennsylvania in the 1958 competition. He also won the top regional honors for Pennsylvania and Maryland, and received an expense-free trip to the Craftsman's Guild four-day national convention recently held in Detroit. Mr. DeFazio is enrolled in the Department of Mechanical Engineering in the School of Engineering at M.I.T.

The M.I.T. sophomore, a campus dormitory resident, received a trophy in recognition of his work from John T. Rule, '21, Dean of Students. The trophy was donated by the Fisher Bodies Division of General Motors Corporation. The program is designed to interest young men in creative designing and craftsmanship.

On the Horizon

March 12-14, 1959 – 11th Annual Fiesta, M.I.T. Club of Mexico, Mexico City, D.F. (For reservations, consult Clarence M. Cornish, '24, Margaritas 257, Villa Obregon, Mexico 20, D.F., Mexico.)

June 15, 1959 – 25th Alumni Day, 1959. M.I.T. Campus in Cambridge.

Grant to Study Africa

■ Africa, which is rapidly taking a position of prime importance in world affairs, will be the subject of an intensive three-year research project at the Institute's Center for International Studies, according to a recent announcement by Julius A. Stratton, '23, President of M.I.T.

The study will be financed by a $200,000 grant from the Carnegie Corporation, made to M.I.T. The project will be directed by Arnold Rivkin, former associate general counsel of the U. S. International Co-operation Administration, who has visited Africa several times. It will be under the general direction of Max F. Millikan, who has been director of the M.I.T. Center for International Studies since its establishment in 1952. Dr. Millikan is professor of economics in the Department of Economics and Social Science.

Research will be focused on the rapid political and economic development of the area of Africa south of the Sahara Desert, with the exception of the Union of South Africa. Teams of economists and political scientists will be sent to the area, concentrating on studies of Nigeria, French West Africa, the Belgian Congo, and the Federation of Rhodesia and Nyasaland.

Professor Wolfgang F. Stolper has taken a leave of absence from the University of Michigan to work on the project. Gordon Unsworth, head of the Africa Unit of the United Nations Bureau of Economic Affairs, and Mrs. Ona B. Forrest, an economist for the bureau, are co-operating in the study. Miss Elizabeth Davis, statistician, is included as a member of the project staff.

"The vast areas which we will study are largely underdeveloped regions with new societies evolving," Mr. Rivkin said. "They have many problems, much potential, and, as yet, little cohesion. They have aspirations for developing a higher standard of living, and this study, by adding knowledge and insights, could make a contribution to such developments."

Questions around which research will center are ones such as: What kind of political framework will best facilitate the rapid economic development and at the same time provide for participation of the individual in decision-making? How can peaceful evolution of the new states in Africa be achieved in the context of changing colonial relationships?

Problems in external trade and intra-Africa trade, commodity price fluctuations, capital formation, private investment, and other economic fields will be considered, with emphasis on economic development and political change.

Taking part in presentation ceremonies during which the Institute acquired an original manuscript by Sir Isaac Newton are (in usual reading order): Azel W. Mack,'15; Sidney M. Edelstein,'32, who presented the Newton manuscript; John E. Burchard, '23, Dean of the School of Humanities and Social Studies; William N. Locke, Director of M.I.T. Libraries; and Giorgio D. de Santillana, Professor of the History of Philosophy and Science. Dr. Edelstein, donor of the gift, is president, and Mr. Mack is Vice-president of the Dexter Chemical Corporation. A reproduction of the last page of the manuscript is shown in the halftone below.

M.I.T. Gets Newton Manuscript

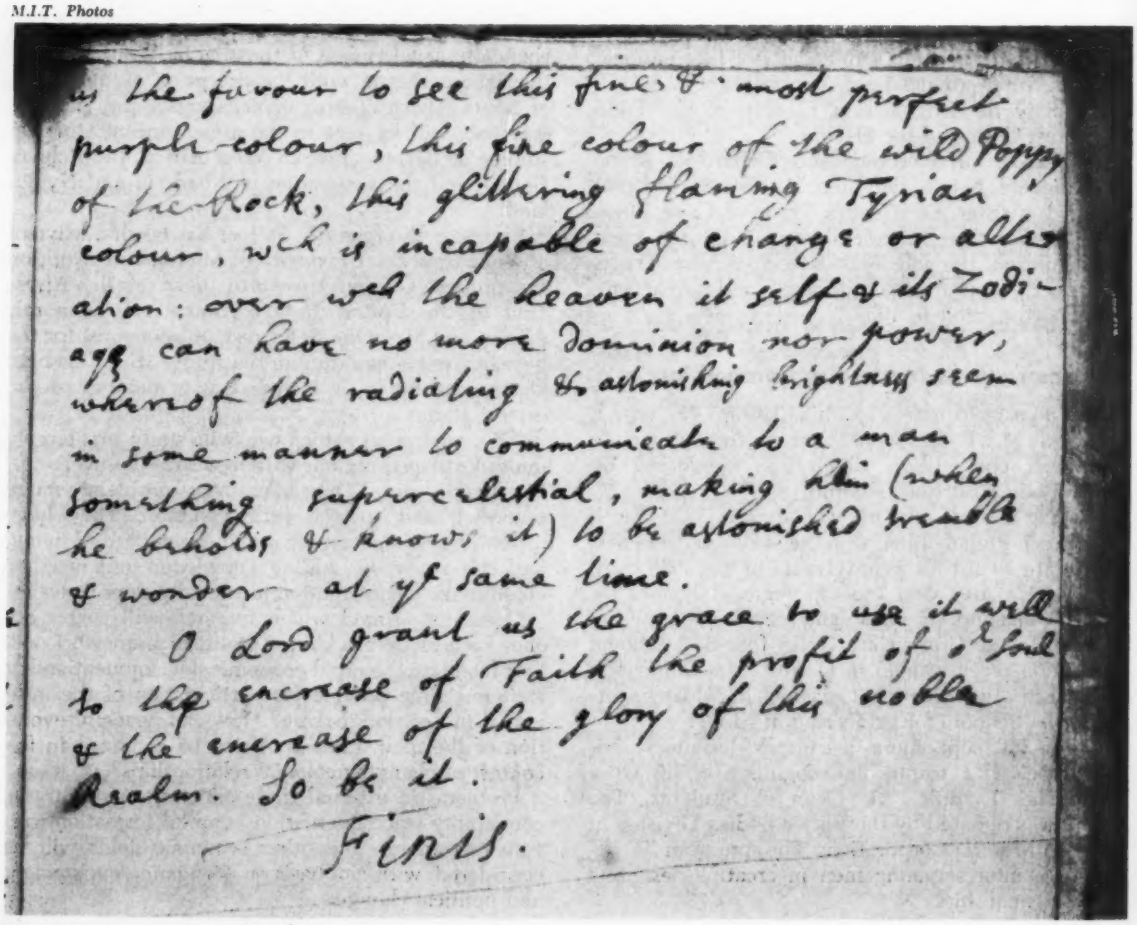
■ An original manuscript by Sir Isaac Newton, great Seventeenth Century scientist, was presented to the Institute by Sidney M. Edelstein, '32, of New York. It will be used in studies of the history of science and technology.

The manuscript is a 61-page, 15,000-word English commentary and translation of a book on alchemy by Nicholas Flamel, Fourteenth Century Frenchman who claimed to have succeeded in doing what alchemists tried to do for hundreds of years – to make gold and silver out of cheaper metals (mercury in this case).

Dr. Edelstein, who is president of the Dexter Chemical Corporation, has been interested, ever since he was a student at M.I.T., in the history of alchemy – long ago discredited but nevertheless important since modern chemistry grew out of it. He has been collecting early books and manuscripts on alchemy and chemistry for 20 years. Dr. Edelstein is a member of the Advisory Board of the American Chemical Society.

William N. Locke, Director of Libraries at M.I.T., who received the gift, said, "We are very happy to have the manuscript, since we have no other original work by Newton in our small collection and it should prove of great value to scholars working in this field."

M.I.T. Photos



us the favour to see this fine & most perfect purple colour, this fine colour of the wild Poppy of the Rock, this glittering flaming Tyrian colour, wch is incapable of change or alteration: over wch the Heaven it self & its Zodiack can have no more dominion nor power, whereof the radiating & astonishing brightness seem in some manner to communicate to a man something supercelestial, making him (when he beholds & knows it) to be astonished trembla & wonder at y^e^ same time.

O Lord grant us the grace to use it well to the encrease of Faith the profit of o^r^ Soul & the encrease of the glory of this noble Realm. So be it.

Finis.

Although there are other translations of Flamel's book, the one by Newton, which has never been published, should prove of special interest because it doubtless reflects Newton's views of science in the Seventeenth Century, Dr. Locke said. Newton was one of the greatest scientists of all time, he pointed out, and many of his conclusions regarding physical laws are as correct today as they were 300 years ago.

Chemistry was in its infancy in Newton's time, however, and he gave serious consideration to the ancient alchemists' superstitions, though he is believed to have been less interested in making gold in the laboratory than he was in determining the unifying chemical laws, just as he unified physical laws through his explanation of gravitation.

Flamel's work was based on an ancient manuscript written on bark by a Jewish scholar, which he succeeded in deciphering after many years of work. This manuscript gave directions for the preparation of the "philosopher's stone," the chemical compound which alchemists believed would change lead into gold, cure diseases, and accomplish other magical effects.

"It is ironical," Dr. Locke said, "that today science has learned how to transmute one metal into another by atomic processes. The goal of the alchemist has been attained, but now there are far more important things for humanity than to make gold. Modern science has made it possible to cure diseases which alchemy didn't even know existed."

Technological Factors in America's Growth

■ Americans' pride in their technological achievements has exceeded their understanding of how they came about, John B. Rae, Associate Professor of History at M.I.T., told historians at the meeting of the American Association for the Advancement of Science held in Washington, D.C., on December 30.

Addressing the newly organized Society for the History of Technology, he said that knowledge of technological aspects of our history has been too fragmentary to enable us to understand fully the evolution of American civilization. A more thorough and accurate understanding of how science and technology have influenced, and been influenced by, the American environment, Dr. Rae argued, would be an eminently desirable step toward an intelligent appreciation of what they may hold for us now.

When the United States was an undeveloped country, he pointed out, there was no "fairy godmother distributing largesse in the form of economic aid or technical assistance." The folk heroes of American technology, consequently, are "the Edisons and Fords, men with a minimum of formal training, dedicated to cut-and-try, and lacking in scientific background and inclined to be scornful of scientific method.

"One consequence," he continued, "was that to the end of the Nineteenth Century the relationship between science and technology was somewhat casual." This attitude has been modified now, but "the emphasis on the practical still dominates American thinking.

"While we can concede that we have unduly neglected 'pure' or 'basic' research in the past and now need to give it more vigorous encouragement," Professor Rae reminded the historians, "it does not follow that the American emphasis on the practical has been wrong. The technique of application may, in itself, be more significantly creative than the original idea or invention."

Citing examples from the aluminum, petroleum, and automobile industries of the importance of technological change in industrial growth, he called for more intensive study of the interrelationships of technology and industry.

"Technological change may, and frequently does, originate in an isolated act of genius, but its effectiveness in an economic sense is a matter of time and circumstances," Professor Rae explained. "We must give more attention to the role of technology in the growth and organization of industry.

"Our failure to do so in the past has resulted in misconceptions and distortions, particularly in the area of big business. The predominant attitude is still suspicious of bigness. We seldom inquire into the possible relationship between the growth and structure of the business and the technological processes in which it was engaged.

"Unless adequate weight is given to the technological factor, it is completely impossible to give an accurate picture of the growth and character of American business enterprise," Dr. Rae concluded.

Nonlinear Random Theory

■ Appropriately enough, Norbert Wiener, M.I.T. Professor of Mathematics, appears as author of the first volume in the Technology Press Research Monographs. Dr. Wiener's newly published *Nonlinear Problems in Random Theory* is the book inaugurating this series, and his third to be issued under the joint imprints of John Wiley and Sons, Inc. of New York, and the Technology Press of M.I.T.

In line with the suggestions of Yuk-Wing Lee, '27, Associate Professor of Electrical Engineering, and Amar G. Bose, '51, Assistant Professor of Electrical Engineering, at M.I.T., and receiving their enthusiastic co-operation, Dr. Wiener undertook to expound on his ideas in a series of lectures given to a selected group of graduate students earlier this year. Dr. Lee, sitting in with his camera, caught in black and white the intricate formulae written in otherwise expendable chalk. A busy tape recorder meantime committed the lectures to durable form and the entire proceedings, translated into print, make up the present book.

Dr. Wiener's work is of wide interest to mathematicians, electrical engineers, atomic physicists, biophysicists, and those in all branches of statistical mechanics. As the author demonstrates, random processes – in space as well as time – enter into the study of statistical mechanics, and open new paths into the study of gas and plasma theory. His methods, though utilizing complex mathematics, are applicable to such practical problems as electric power in homes, television sets and FM radio, and washing machines.

Nonlinear Problems in Random Theory further reflects Professor Wiener's absorption in the mathematical analysis of brain waves. In this connection, he perceives a mathematical similarity between the orbits of the asteroids and the behavior of the oscillators in the brain, and observes other fine shadings that elude even the keenest eye.

Biological Tissue Hardened

■ Imitating what is believed to be nature's way of making bones and teeth, materials taken from soft biological tissue have been hardened in a test tube. Recent achievements in hardening reconstituted biological material in the laboratory were reported at a meeting of the American Association for the Advancement of Science, in Washington, during its 125th annual conclave on December 30, by Melvin J. Glimcher, '57, biophysicist and orthopedic surgeon who is now a fellow in the School for Advanced Studies at M.I.T.

Dr. Glimcher compared the processes, by which soft tissues in the body are hardened to create a skeleton, to ways in which chemists have strengthened a great variety of materials for the builders of machines. Long threads consisting of groups of atoms linked together – which the biologists call macromolecules – are found in both the soft and the hard parts of animal bodies. In the bones, shells, and other hard parts of animals, these macromolecules have been so aligned and woven together that they resist stresses and provide protection for other parts of the body, give it form, and make locomotion possible.

In the bones and other hard parts of the body, moreover, these threadlike macromolecules contain hard crystals which make them less flexible than the chemically similar threads found in the flesh and skin. According to Dr. Glimcher, these crystals are formed the way that ice is made from water when clouds are seeded. Crystals of the ice arise most readily around minute particles of foreign matter having a configuration which makes it easy for the molecules of the water to solidify around them.

In the M.I.T. laboratories, threads of macromolecules taken from soft biological tissue have been hardened in a test tube by deposition of crystals within them. These bits of man-made, bonelike material are too small to be seen. Under an electron microscope, however, they resemble the material in the bones of living things, and the hardness of the synthesized biological material has been established by electron and x-ray diffraction studies of it.

By examining the molecular construction of the macromolecules and that of the chemical solutions in which crystallization occurs, and those in which it fails to occur, a better understanding of the way in which the material in a bone is hardened has been acquired.

Work such as Dr. Glimcher and his colleagues are now doing could lead eventually to new methods of promoting the reunion of broken bones, the treatment of bone ailments, and also such diseases as arteriosclerosis, which result from abnormal hardening of biological tissue in parts of the body where normally soft tissue is required for health.

Dr. Glimcher turned to biophysics after preparing for a career in orthopedic surgery, and has been working for the last few years under the direction of Professor Francis O. Schmitt, Professor of Biology, M.I.T.'s distinguished authority on collagen.

Twenty-five Years Ago This Month . . .

■ On February 17, 1934, at Walker Memorial there took place the 58th Annual Alumni Dinner, with 850 present – a record attendance except for the 45th Dinner at Walker on January 10, 1920, when 1,070 had foregathered to hear the mysterious "Mr. Smith" revealed as George Eastman.

According to The Review, the 58th Dinner "was also one of the most enthusiastic. Classes not only competed for attendance (1926 won with 43) but for decibel delivery (1914 taking the honors). The Institute's first class, 1868, had the highest percentage of its membership present (one out of two), with Robert H. Richards occupying his usual coign of vantage.

"Redfield Proctor, '02, President of the Alumni Association, presided at the dinner and he presented as speakers Dr. Frank Aydelotte, President of Swarthmore College, Dr. Compton, President of the Institute, Dr. Bush, '16, Vice-President and Dean of Engineering, and Dr. H. E. Edgerton, '27. President Aydelotte, who once taught English and history at the Institute, spoke out of his considerable experience with engineering education and strongly recommended a more cultured, well-rounded education of the engineer. With undesigned appropriateness, President Compton spoke of the Institute's efforts to prepare men not only to be engineers, scientists, and architects, but to be useful, happy citizens as well.

"At the beginning of his address, Dr. Compton paid tribute to the late Everett Morss, '85, for many years Treasurer of the Institute and a member of the Executive Committee of the Corporation and for two terms President of the Alumni Association. Dr. Compton made public for the first time the story of the Blashfield murals which adorn the walls of the great hall in which the dinner was held.*

"Mr. and Mrs. Everett Morss had taken so much pleasure in the Blashfield murals in their own home that they conceived the idea of bringing similar pleasure to the thousands of Technology students who use the great hall of the Walker Memorial for dining and social functions. Mr. Morss, therefore, wrote to Mr. Blashfield to find out under what terms he would paint the proposed murals. Blashfield, himself an M.I.T. alumnus, Class of 1869, replied that he had always wanted to do something for the Institute and that he would, therefore, be glad to donate his services, provided the actual cost of materials and labor of assistants could be taken care of. This expense, which ran into many thousands of dollars, was quietly taken care of by Mr. Morss himself.

"Thus these splendid murals," Dr. Compton continued, "which are distinctively the creation and gift to the Institute of Mr. Blashfield, should be at the same time an added reminder to Technology of the thoughtful, energetic, and varied contributions to its welfare made by Everett Morss."

* Mr. Morss was the 14th President of the Alumni Association, serving in that office for the calendar years 1906 and 1907. In 1908 he became a member of the Institute's Corporation, and in 1910 of its Executive Committee. From 1921 until his death on December 27, 1933, he was Treasurer of the Institute.

To Study Lost Wax Molding

■ New techniques to take the place of 5,000-year-old methods of casting art objects in metal are to be sought at the Institute. A $10,000 grant has been made by the Rockefeller Foundation to support research by Alfred Duca, Boston sculptor, in the M.I.T. foundry laboratory.

According to Professor Howard F. Taylor, 2-46, who announced that Mr. Duca had joined the staff of the Department of Metallurgy as a research associate, the research will concentrate on the simplification and improvement of the "lost wax" process of molding sculpture, first used in Egypt and China thousands of years ago.

The traditional lost wax method is used principally to make hollow castings, Professor Taylor explained. A plaster model is made of the desired object. This model, or armature, is then coated with wax, which is sculptured and covered with plaster. Heat is used to harden the plaster mold and to melt the wax, which runs off, or is "lost." Molten metal is then poured into the mold, taking the place of the wax. When the metal has hardened, the mold is removed.

"The lost wax process, and for that matter, practically all casting of sculpture, is nearly a lost art in America," Professor Taylor said. "Young men have found that they can earn more money working on mass-production assembly lines than as apprentices or artisans in art casting, with the result that it is difficult to find a foundry in the United States to cast a work of art at a reasonable price.

"The consequence is that most casting of fine sculpture must be done in Europe. An American sculptor who has done his work in clay or wax must send it to Italy, Portugal, or France, where art casting is still a highly regarded craft. It is generally desirable that he oversee the work himself. Going to Europe, or even sending sculpture there for casting, is expensive and time-consuming. This is one reason that sculpture has languished in the United States.

"Mr. Duca has been doing some preliminary research in new methods and we believe that with the help of metallurgists he can apply new technology to a very old art in ways that will help American sculptors."

Mr. Duca will work under the general supervision of Professor Taylor and Merton C. Flemings, '51, Assistant Professor of Metallurgy. They are in charge of the foundry laboratory, which in recent years has been a center for the development of new techniques for industrial foundry work. Professor Taylor holds the professorship of foundry metallurgy which was established by the American Brake Shoe Company.

A graduate of Pratt Institute and the Boston Museum School, Mr. Duca has executed hundreds of paintings, prints, and sculptures, using a wide range of materials, and his work has been exhibited in many galleries in the United States and Europe. He is the inventor of a process for the use of polymer tempera, a plastic, in painting and sculpture. Four years ago he began independent research in metal casting, and earlier this year presented his first one-man show of bronzes (most of which he had cast himself) at the Boris Mirski Gallery in Boston. He has lectured at M.I.T. and Boston University.

M.I.T. Photo

Frederic H. Fairchild, Colonel, U.S. Air Force (left), assigned to M.I.T. where he is head of the Department of Air Science, pays a call on J. A. Stratton,'23, President. Colonel Fairchild has been appointed as professor of air science at the Institute. He is a graduate of the U.S. Military Academy at West Point, and attended the Air War College and Industrial College of the Armed Forces. Previously, he served as inspector at the Missile Test Center, Patrick Air Force Base, Fla.

Computer Studies of Traffic

■ Using a high-speed computer to simulate the flow of automobiles and trucks through tunnels, over bridges, and on single-lane roadways, a research group at the Institute is studying traffic patterns with a goal of nailing down the parts played by individual drivers and vehicles in heavy traffic.

The Institute's Operations Research Center is conducting the study with the help of the Port of New York Authority. Current work is focused on such places as the Holland and Lincoln Tunnels and the George Washington Bridge, but the research is applicable to conditions at heavy traffic areas around the country. The study is being conducted by Herbert P. Galliher, Jr., Assistant Director of the Center, who is responsible for the study, and Walter S. Helly, 28-year-old physics graduate student at the Center, who is research assistant in the Department of Physics. They are using the I.B.M. 704 Computer at M.I.T.'s Computation Center to simulate certain traffic conditions and study them.

"In addition to being a problem of intense personal concern to us all," said Dr. Galliher, "traffic flow invites the use of computers, mathematics, and psychology to analyze the causes of bottlenecks. As everyone knows, traffic problems are not simple." The versatile computer at M.I.T. actually generates a picture of traffic situations, simulating the position of each car at intervals of a quarter of a second, and drawing lines between the points, so that delays and varying distances between vehicles can easily be seen.

The essential task, the researchers explained, is to build into the simulation the proper characteristics of individual drivers. The Port of New York Authority has been assisting in a program to determine

these characteristics. A special camera, mounted high in the New York tower of the George Washington Bridge, automatically recorded 90 times each minute the positions of cars crossing the bridge. When traffic speeded up or slowed down, an "accordion" effect was produced in the line of following traffic which will be analyzed to determine driver reactions to a continually changing traffic situation. Information obtained from the pictures is being reduced to data that will be fed into the computer, and this will simulate traffic conditions that will keep Mr. Helly busy for some time.

The immediate goal of the studies being conducted by Mr. Helly is greater knowledge of the nature of congested traffic flow, and measurement of factors that control it. For example, how much would a given flow be speeded up if stop and brake lights were placed so as to allow drivers to see them many cars ahead? How much do trucks slow down the over-all flow? How much and how safely would compulsory minimum speed limits improve flow? How much does high horsepower contribute in permitting quick closing of traffic gaps by fast acceleration? How much additional flow would it be worth if driver reaction times could be speeded up? How much additional flow would result from giving drivers more information—even signs with general advice as well as warnings of specific hazards or intersections ahead?

"The simulation is an inexpensive way to answer these questions," explained Mr. Helly, "and as the Port of New York Authority emphasizes, even small increases in current flow are very valuable to the persons waiting for passage during heavy traffic periods."

The American Style

■ Do Americans have their own characteristic ways of solving problems?

"Yes, but those ways are changing," is an answer to this question given in a new book, *The American Style*, which is the product of a conference held by the M.I.T. Center for International Studies.

The conference brought together 30 of the intellectual leaders of the United States, last year, for four days of discussion at Endicott House, which is the M.I.T. guest house in Dedham, Mass. Participating were such people as: J. Robert Oppenheimer and George F. Kennan of the Institute for Advanced Study in Princeton; Dean McGeorge Bundy and David Riesman of Harvard University; Alfred H. Barr, Jr., Director of the Museum of Modern Art; and Wiliam S. White, political columnist. James R. Killian, Jr., '26, and Julius A. Stratton, '23, at the time, President and Acting President, respectively, were among the M.I.T. representatives. Max F. Millikan, Director of the Center for International Studies, was chairman.

The central theme of the conference was analyzed by Walt W. Rostow, Professor of History at M.I.T., in an essay which appears in the book under the title "The National Style." Compromise and practical experimentation have been two of the principal American methods of dealing with problems, he asserted.

"Both the adjustment to conflicting regional and group interests within our national society and the process of social mobility have been enormously aided by the sustained growth and high output per head which has marked the history of modern American economy," Dr. Rostow wrote. "This not only gave reality to the concept of progress but also permitted men to achieve compromises in which they shared the increments to communal wealth without the bitter, corrosive conflicts which come about when men feel they can rise only at the expense of someone else's decline."

Citing various chapters in American history, Dr. Rostow expressed the opinion that decisions are likely to be made on the basis of "experience, feel, judgment, by sensing recurrent patterns" instead of by "clean-cut logical connections of cause and effect." He observed:

This is how good captains of sailing vessels have worked – good politicians, good businessmen. This has been the typical American style in operating and developing the nation's society. Its success, however, is dependent on two conditions which are, to a degree, alternatives. First, the problems confronted must be, in their essence, relatively familiar and capable of solution by only moderately radical innovation on the basis of existing principles or institutions.

Second, there must be sufficient time for the experimental exploration of possible solutions and the osmotic process of accepting change. The more time permitted, the greater the workability of a technique of problem solving by empirical experiment. . . . The American style is least effective when it confronts issues which require radical innovation promptly. . . .

On domestic matters the classic style still operates. And over a wide range of issues, it operates with a heightened effectiveness. The two major parties continue to work as intermediate instruments of compromise and reconciliation on a continental basis. . . .

In foreign policy a different aspect of the national style gives us chronic difficulty – the relative ease and continuity of our political and social experience. We had to fight for independence, but from early colonial days the basic presuppositions of American life were those of an individualist society. We never had to struggle to free ourselves from a feudal society and political past. . . .

Thus, we face a world where something like a billion and a half human beings are caught up in one version or another of an effort to break old, static molds and to modernize their societies; we can find little instinctive in our history or in our political or economic processes which fully meets their case. . . .

From our wartime relationship with the Chinese Nationalists down to the Middle East crisis and the foreign aid bill debate, we have had difficulty in understanding the complex processes at work in the underdeveloped areas and in harmonizing our efforts with those of the men and women caught up in the great nationalist revolutions now going forward in strategically decisive areas of the world.

We have, to our cost, been excessively culture-bound in facing this mammoth fact of the Twentieth Century.

It will take more reflection and imagination – more application of the vicarious rather than instinctive knowledge – than we have thus far brought to bear on national policy to protect the national interest as these revolutions evolve over the coming decades . . .

Other essays in the book were written by Dr. Oppenheimer and Mr. Kennan; Abraham Kaplan of the

(Concluded on page 214)

The Challenge

We need science and technology to maintain our military muscles, to feed the world's people, and to conserve its resources. But we also need both to wage effective peace

by JAMES W. McRAE

In talking about the challenge of the future, it may be well to begin by going back 1,000 years to the now extinct civilization of the Mayan people who lived in Yucatan, Mexico. It is surely fair to say that the jungle has not been very kind to the monuments those people left. They are now badly crumbled and no one is sure what caused the Mayans to abandon them so suddenly. The generally accepted opinion seems to be that the problem was a social one; that the ruling classes, who were theocrats, drifted away from the people. Indeed, it seems that the rulers shifted the basis of their religion from its old preoccupation, with the problem of securing good crops, to one which emphasized war and warriors. This change did not appeal to the population which was essentially agricultural. Finally, it is believed that, at a propitious time, the populace rose up and killed off its ruling class. The Mayans then were left without a creative minority and reverted to a primitive culture.

Such reversions to a primitive culture have happened many times the world over in the course of history. So we may well ask, what is likely to happen to our culture? If we were to ask that question of Khrushchev he would answer it promptly. He does not see a very long future for us. He thinks we will give up the heritage of Western civilization in favor of Soviet-style Communism, and if we don't do so voluntarily, the Communists will see that we do, or that we are buried properly. This is a real and immediate threat to our culture and one we have to face realistically. It brings us face to face with the military challenge.

Before we go further into military problems, we have to remind ourselves that there are two requirements for any culture. One is to maintain the right amount and kind of military strength. By this is meant not necessarily the military strength to handle only one threat, but the strength to handle a whole range of possible threats. The second requirement is to avoid focusing too much attention on military matters. We must not overlook long-range problems which peaceful existence imposes. Indeed, we must avoid the mistakes made by the Mayans in their failure to attend to other aspects of their culture besides war and warriors. This is another part of our challenge.

In this regional meeting, our attention is to be devoted primarily to science and technology, and particular emphasis is to be placed on peaceful applications of science. This is as it should be. But before we shift to our major topic, we should recognize the military challenge facing us. At the moment, a good deal of our applied science and technology is devoted to meeting this military challenge, and residents of New Mexico are keenly aware of the importance of scientific contributions to warfare. After all, this is the state in which the nuclear weapon was born and nuclear weapons have dominated questions of military strength ever since 1945.

All of us remember the history of nuclear weapons. The bombing of Hiroshima and Nagasaki almost certainly saved many American lives, but immediately after these explosions there was a popular revulsion against atomic weapons. As time went on, revulsion was replaced by hope; hope that nuclear weapons, under international control, would be the means for eliminating large-scale warfare. However, the Russians would have no part of such a plan and we were left to build up a one-sided deterrent to military aggression in the form of our stockpile of nuclear weapons. By now this has changed, and today we no longer have a one-sided deterrent. The Russians have their own stockpile, and now Russia and the Western world look at each other across two military stockpiles of nuclear weapons – theirs and ours.

To its big bombs and big bombers, Russia is also adding a family of very big missiles. One of these could carry a big nuclear war head all the way from

Bell Telephone Laboratories

Control desk of NIKE electro-mechanical simulator represents an example of the use to which science and technology have been put to maintain strong national defenses.

As we go forward with industrialization . . . inevitably the rate of use of the world's natural raw materials will again be increased by large factors, inevitably some natural resources must be expected to become depleted. For example, our supply of iron cannot last forever.

Neither, for that matter, can our supply of copper on which the electronics and electrical industries depend so heavily. But by applying the best and latest knowledge of science and technology, as is done in this copper pit in Morenci, Ariz., it is possible to use raw materials more efficiently and to engage in effective conservation measures even though the rate of use increases.

Bill Sears from Black Star

Russia to our homeland and could deliver the war head so quickly that our warning would occur only 10 to 20 minutes before it arrived. This is a new factor in our thinking about what I call the "big" war. There is no question whatever but that, in the near future, Russia will be able to launch a devastating attack against this country from bases within her own national boundaries. What is our reply?

Defense and Offense

We are replying in two basic ways. First, we are working to improve our defenses by applying new science and the best technology to develop defenses against big ballistic missiles, as well as against big bombers. But no one can guarantee 100 per cent effectiveness for an air-defense system, and certainly not in advance of its trial in combat. So we need another kind of defense – an offensive kind of defense – and this is provided by our retaliatory force, which includes primarily the Air Force Strategic Air Command, but also many Navy and Army units.

Much effort is being devoted to assure the survival of this retaliatory force, no matter how heavy may be the initial attack against us. There are special operating procedures for big bombers, as well as a maximum effort to develop our own ballistic missiles. We intend to disperse our missile bases on land, and to hide some of them at sea on submarines. We also plan to make some of them impervious enough so that they will be able to launch missiles after a near-miss by an enemy hydrogen bomb. This is all to insure that any attack by an enemy using nuclear power will, with certainty, be followed by an effective attack of our own.

My personal opinion is that the Russians know that something we can honestly call "massive retaliation" would inevitably follow a surprise attack on us. They must know of our concentration of scientific, engineering, and military effort on defenses against their missiles, and the development of our own weapons. They can see the United States spotlight focused on these efforts. Their intelligence people – their G-2's – *must* have to report to the Kremlin that we shall surely achieve what we are after in these respects. In short, I believe we are well on our way to big war stalemate and effective deterrence of the big war.

Now you may think that the Russians would be unhappy about this; but I wonder. Perhaps they are secretly happy that we are giving so much attention to the big war. Perhaps they hoped we would do just what we are doing – devote our principal efforts to the big war problem. Perhaps they are glad that we are, in a sense, blinded by the glare of Sputniks in the sky, and that we continue to give national attention primarily to big bombs, big bombers, and the big war of international annihiliation.

New Strategy Needed?

Pehaps in the future the Russians intend to follow the strategy they have used consistently since World War II. So far as one can see, they have not seriously considered an actual attack on our homeland. Instead, as you know, they have combined local military pressure with subversion and propaganda to attempt to push us back on local fronts. We have had to react to these attempts in diverse ways: by providing military and economic help to Greece; by promising aid to Iran; by refusing to bow to transport problems in the case of the Berlin air lift; by taking military action in Korea; and last but not least, by providing convoy action at Quemoy.

Now the variety of these situations is impressive. They are all different. They are different in the nature of, and our reaction to, the threat. About the only characteristic they have had in common is that they were all limited. On both sides, actions were limited in area and in objectives. The national existence of no great power was in question in any of these actions. No one mentioned unconditional surrender. Neither side used, nor seriously threatened to use, its big bombs. This is actually the kind of action – military action – to which we, as a nation, should be accustomed.

If you examine the record, I think you will find that World Wars I and II were the exceptions to, rather than the rule of, U. S. military action. It has not often happened that the surrender of one of the world's great powers was the objective of our military action. Usually, as in the engagements the Marines celebrate – the "Halls of Montezuma" and the "Shores of Tripoli" – we have used military force to assist our diplomats in arriving at some international agreement. Our long history indicates the importance of being prepared for such limited engagements, and Russia's recent series of acts has confirmed this for us again.

Preparation for limited war, in my opinion, should be the subject of much more national attention. If it were, many important questions would appear and could be debated in quite different circumstances. For example, should we have an elite force equipped with the lightest and best weapons suitable for limited war and provided with its own transport aircraft? Suppose this force started out as a small one which exercised and maneuvered as realistically as possible. One day, for example, it might be holding exercises at home. The next day, it might fly into a remote part of Africa, and a few days later be in Asia. As time went on and the unit learned more and more about its equipment and its problems, this force might be expected to grow in size and competence. The essentials of this plan would be to start with a small force, exercise it realistically, and let it grow as opportunity and necessity might dictate. This is the plan we have followed in the case of the Strategic Air Command, aimed at big war deterrence. Why not do the same thing for small war deterrence?

Another matter for open debate and public understanding is the necessity for close collaboration between military, political, and diplomatic groups in limited warfare. Since a limited war is fought to achieve an *agreement;* an agreement which would be more favorable than we could achieve without the application of force, the importance of military-diplomatic collaboration is clear. However, the objectives of this collaboration need to be well considered.

The Korean War, I think, is a case in point. Much was heard about the fact that, by political action, it was limited in area. Our military forces were not allowed to bomb beyond the Yalu River. I think you will agree that we heard impassioned denunciations of this political limitation. However, I am not sure that this criticism is the most important, nor the most serious, that we could make of the Korean operation.

To illustrate this matter, consider our behavior when we finally sat down to negotiate. At that time, we had effectively removed our military force as a factor in the bargaining. Perhaps it would have been more effective to say: "We agree to negotiate with your side but we intend to maintain our military strength in Korea, and failing an agreement in 30 days we reserve the right to take military action again." Perhaps a combination of political and diplomatic negotiations, *plus* the threat of military action, might have required less time at the conference table and produced a more favorable final settlement.

Through scientific efforts we have improved considerably the vigor and yield of most crops and we now handle and process them much better than in the past. We preserve foods better and, indeed, we now have respect for vitamins. Nevertheless, we still plant essentially the same crops as did our ancestors.

It seems certain that world problems of food production will inevitably be mitigated by knowledge resulting from intensified studies in the life sciences. We can even dare to hope that such knowledge will give us clues to new kinds of food which can be produced in some other medium than through the growing of green plants in the soil.

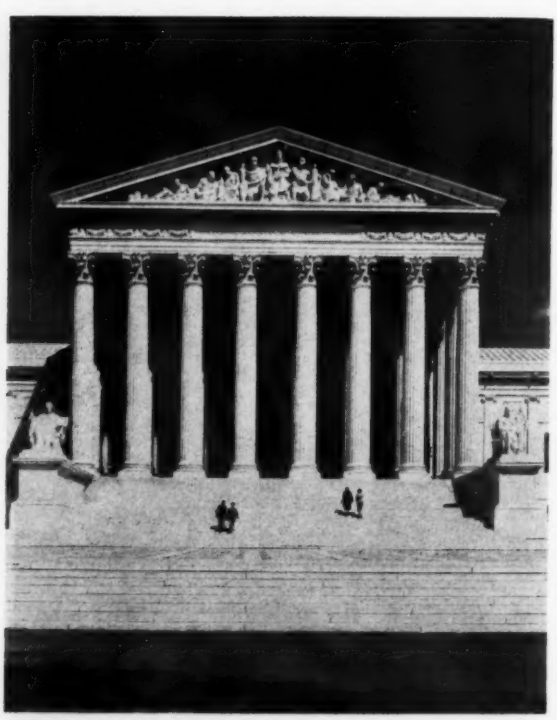
Soil Conservation Service

Human Relations with Other Nations

As soon as we introduce ideas of political-diplomatic action into a discussion of miltary matters, we immediately broaden the discussion to another area of challenge to our culture. This is the challenge that is evidenced by our problems regarding international politics, our international trade, our diplomacy; in short, our human relations with other nations and other peoples.

How should we behave in the Middle East where rising Arab nationalism appears to be revolting against ideas developed during the long period of European domination? How should we work with the countries we class as neutralist or uncommitted?

The relations we have with other nations of the world involve technical, as well as human, problems – both of which are interrelated, of course. In our relations with other peoples, let us look first at the technical problems. One reason for discussing technical problems is that, in my opinion, they emphasize our very great need for much more science and technology in the future. You notice I have used the word "need" – our "need" of science and technology for the future survival of our culture. We need not talk about the cultural values which science brings to our civilization. I am not here to expound on the virtues of this intellectually honest discipline so effectively combined with highly creative activity. Much as I would like to relate the joy of achievement which scientists and engineers so often experience, this is beyond the scope of my discussion. The point I wish to emphasize is that we need more science and more technology, not because these pursuits are worthy, but simply as a requirement for the future survival of our culture.



A. Devaney, Inc., N.Y.
Our challenge is to use our technical resources so that we remain strong, not only as a military power, but also as a peaceful civilization.

I have already implied that military matters should engage the attention of our scientists and engineers. It is not enough for them to be concerned only with the "big" war; they must also keep in mind our need for other kinds of military strength. Even more important, they must look beyond the military and see the political problems. For example, I believe it is imperative that we reverse the roles in which we and the Communists are cast throughout the newly nationalistic and neutralist world. At present we bear the stigma of European imperialism, while the Russians hold out the promise of an ideal state to come. For some reason, the Soviet record of human slavery and slaughter is overlooked in contemplation of their idealistic dream of a new and perfect state. On the other hand, to many underdeveloped peoples our standand of living appears to be nothing but an unhealthy materialism and our emphasis on economic and military aid often fosters the same opinion. Even with our deep belief in such ideals as the dignity of the individual, to the rest of the world we seem to be the materialistic group and the Russians the idealistic.

Strangers to our culture find it difficult to understand the actual society in which we live. The tendency is to assume that our capitalistic society is like the one Karl Marx wrote about, whereas it is quite different. It is difficult to figure out how we can counteract such a broad-scale misconception, and it is probably not a problem for an engineer, alone, to discuss.

However, there may be a possibility of changing some misinterpreted views in this connection, particularly those based on lack of understanding. This may require us to concentrate more of our scientific and technical effort to solve the very severe technical problems facing those peoples who have not yet been as fortunate as we in benefiting from science and technology. There are many such problems. One is the pressure of population.

Population Trends

Our own population is growing rapidly but the rest of the world is in the midst of what amounts to a population explosion. Merely to keep constant the standard of living, the world is going to need a lot more food. However, few peoples in the world will long be satisfied with their present standards of living, so still more food will be needed. Despite efforts to reduce the rate of growth, it seems inevitable that populations will continue to increase, that there will be corresponding needs for greater amounts of food, and pressing needs for more effective distribution of the available supply. The problem of distribution involves not only transportation but trade, and again this introduces nontechnical questions.

Returning to technical matters, we may remind ourselves that we still eat essentially the same foods our ancestors have been eating for hundreds of generations. In fact the biggest change in the food habits of the Western world occurred when our Eu-

(Continued on page 208)

The Problems of College Admissions — I

Today, college admission is a complex operation with many facets in which parents, teachers, high school counseling personnel, and various examining bodies all play their roles

by B. ALDEN THRESHER

EACH year there occurs in the United States a "great sorting" by which nearly 1,000,000 boys and girls distribute themselves among some 1,800 institutions of more or less higher education. This is a social process of great complexity. The cultural and sociological forces which influence it are not wholly understood though some progress has been made in this direction. If a student and the college can be thought of as the primary actors in this drama, there are a great many other people who intervene at various stages in the process of mutual selection and who influence in greater or less degree the decisions that are made on both sides.

Because of the immense and healthy diversity of American education, we do not have the severe restriction of alternatives that characterizes higher education in many European countries. One consequence of this is that in the United States students, for the most part, select colleges. Only a few fortunate colleges can select students to any appreciable degree. This healthy diversity, whatever its inconveniences, is a chief source of progress; so far we have resisted the rigidifying process that is so likely to freeze educational experiment in older cultures where central control of policy and standards predominates.

M.I.T. Photo

For every student who enters M.I.T., the Admissions Office has spent much time and effort in counseling other students on collegiate education, but it regards its work as useful even though students may register at some other university.

The Admissions Problem

Thirty years ago college admission, on the surface, at least, was a simple matter. Each institution had what was known as admission "requirements" expressed as a list of high school "units" which a student was supposed to have completed before he could be accepted. Although in form these requirements were dictated by the colleges and universities, they were actually composed of the subjects conventionally studied in secondary schools; each institution presented minor variations and rearrangements of these as its criteria for admission. Examinations were often set by individual colleges, and by 1900, a number of institutions had established the College Entrance Examination Board to regularize this procedure, and to reduce the arbitrary and capricious variations in admission requirements.

Today, college admission is a complex operation with many facets. It is a multilateral activity involving not only the institution and candidates for admission, but parents, teachers, high school counseling and guidance personnel, testing and examining bodies of various kinds, and a broad fringe of interested friends and relatives. Admission, furthermore, is no longer a bilateral operation between the institution and the student. It takes place, rather, in a complex social environment in which the student looks at many possible institutions of higher education and makes some kind of a tentative selection among them, while each institution in turn looks at a great many potential students, and if it is fortunate enough to attract many, can exercise some degree of selectivity.

The admission operation at M.I.T. is a part of this complex process and cannot be thought of realistically in isolation from it. Students who applied for admission to M.I.T. last year applied on the average to 3.6 institutions, were accepted by 3.2, and entered one. To those to whom we offer admission in a typical year, some 125 other colleges will also have offered admission, and there will be something over 200 other institutions to which one or more of these young

H. Armstrong Roberts

Those who aspire to enter M.I.T. should have a considerable interest and aptitude for mathematics and science in some form, but aside from this, entering students show a wide range of diversified interests and objectives.

people will have at least made application. We are thus enmeshed in a network of comparisons, choices, and decisions, involving hundreds of institutions and thousands of candidates for admission.

One consequence of this situation is that the process of *selecting* an entering class, while important, represents a very minor fraction of the total time, effort, and funds expended in the admissions process. The overwhelmingly large proportion of our work goes to educational guidance in the broadest sense, including contact with secondary schools, teachers and counselors, prospective students and their parents, relatives and friends. Our mission includes the provision of information on a broad scale, not only about M.I.T., but about other institutions, and about the manifold opportunities awaiting those whose education is in some way oriented toward science.

It is extremely important that the student and parent who seek information about M.I.T. should be able to establish some real personal contact and the kind of psychological *rapport* which this connotes. We therefore keep an open door, encourage visitors, and are glad to sit down and discuss the educational problems of any potential freshmen at whatever length is necessary. This includes not only answering his factual questions but drawing him out about his interests, his activities, his ambitions, and his problems.

People plunge into the maelstrom of higher education with widely varying degrees of preparation. Some have given careful and systematic study to college catalogues, visited colleges, talked with informed friends and relatives, made maximum use of their high school guidance facilities, and in many other ways have prepared themselves to make a rational and wise decision about higher education. Others, having picked up random rumors, prejudices, and bad advice of assorted varieties, tend to ask immature and shortsighted questions, and in general to misread the values that lie partly hidden in the world of educational opportunity.

Every institution has the problem of combating oversimplified or outdated stereotypes which continue to misrepresent its true nature to the public. We have perhaps an unusually difficult problem in this regard at M.I.T. because M.I.T. has undergone such a radical and rapid evolution in the last 30 years. People know a lot about M.I.T. and most of it isn't so.

Thus our total educational mission is not confined to the teaching done within our own walls, but includes an obligation to convey to a wide segment of the general public some broad appreciation of the values inherent in higher education oriented around science. More important than the duty of excluding less qualified applicants is the function of attracting well-qualified ones. This, in turn, cannot take place unless a wide range of youngsters acquire reasonably realistic ideas about scientific education. The boy who comes here for the wrong reason, or because of a mistaken idea of what he is getting into, is seldom a good risk.

One corollary of this situation is that we spend a great deal more time on students who do not enter than on those who do. This is as it should be. In other words, our admissions operation forms an important part of the much larger process by which students consider many institutions and institutions consider many students. This process of "shopping around" and mutual appraisal is bound to take up a certain amount of time, energy, and cost on both sides. It is, however, quite unrealistic to regard time and effort spent on information and guidance as wasted, even though many of the students with whom we deal end up elsewhere.

Is There an "M.I.T. Type"?

Admission to M.I.T. must be studied in relation to the kind of institution which M.I.T. is and is becoming. M.I.T., although still in name an institute of technology, has undergone a profound revolution in the past generation. In Dr. Killian's striking phrase, we now have a "university polarized around science," as its unifying principle. Just as the classics, that is the history and literature of the ancient Mediterranean world long served as a central focus for university education (and indeed for almost all European culture), so at M.I.T. the extension of science, its history, philosophy, applications, and its ramifying influences in politics, industry, and the arts, provide a central theme. This theme acts as a harmonizing and unifying influence to draw together the varied interests of our five schools and 21 departments.

This fact profoundly affects our admissions policy. People frequently ask us what type of student M.I.T. is looking for. We are not looking for any single type but rather for young people of exceptional ability and promise in the entire broad spectrum of human personality, interests, and aptitudes. Our student group has only one basic thing in common, that is, that all of them must have a considerable interest in, and aptitude for, mathematics and science in some form. There is not a single curriculum at the Institute that does not contain a substantial sequence of mathematics and physics. Whatever his other qualifications,

and we hope he will be versatile and have broad interests, a student must be able to cope with this kind of rigorous, quantitative thinking and find it interesting, otherwise there is no place for him here.

Once we grant this unifying central tendency, however, we still are left with a vast possible range of human diversity. At one end of the spectrum are the people who will make research scientists. These are very rare and have exceptional intellectual qualities. They will normally go on to a doctorate here or elsewhere, and there never are enough of them. Then we have various categories of people in the more technical phases of engineering, research, and design, whose qualities approximate those of the scientist, though often with more of the synthesizing, integrative qualities of the engineer. We have people, some of whom are engineers, some not, whose bent is for operation, or construction, or production, or management, as well as architects and city planners. All of these people need broad education in science and the arts, in the ways of man in society, in the policy problems of government and industry.

We have, furthermore, people with many interests that include science but who do not intend to become professional scientists or engineers. Some of these take double majors in humanities and science on either a four- or five-year basis. We have students who go on to journalism, law, teaching, medicine, or to research in the biological sciences, and a host of other possibilities, including the foreign service, the ministry, finance, and insurance. In other words, given the basic fact of an interest in mathematics and science as the central theme of an education, our students encompass a very wide range of subjects and move into every conceivable kind of occupation. We do not regard these as odd deviants from a normal professional groove. On the contrary, we feel that M.I.T. makes a major contribution to the public welfare by seeing to it that responsible people in many walks of life have had the kind of grounding in science as part of a broad liberal education which will best fit them for leadership in the contemporary world.

What we are seeing, therefore, at M.I.T. is an increasing recognition of the *exploratory* function of education and of the postponed professional commitment. A generation ago, our curriculum was a congeries of professional programs in science, engineering, and architecture; this still remains its dominant theme. But there is a considerable and rapid increase in the proportion of students who look at an undergraduate education, not simply as a professional training or even the first stage of a professional training, but as an exploratory process which gives them a many-sided acquaintance with the intellectual world, and by giving them an opportunity to try their wings in a number of areas to form a more just conception of the kind of life work which would best suit them. While M.I.T. continues to provide the preparatory function of education, it is rapidly increasing its attention to the exploratory function.

Along with this goes the tendency to postpone a commitment to a particular professional field. Nominally, all our undergraduates choose, at the beginning of the second year, a professional area of concentration, but if we study the history of our Alumni after graduation we see that the pattern of M.I.T. as a purely professional training has never been closely adhered to. Our people have always gone into an immense range of activities – in business, industry, the professions, commerce, and the arts. What has happened in recent years, however, is that the design of our curricula has begun more realistically to take account of this long-standing tendency and has provided programs in which the exploratory function of undergraduate education, and the more generalized approach, are explicitly recognized. The tendency, already highly developed in science, for an increasing proportion of people to need postgraduate study is rapidly spreading to all the engineering fields, and it is seldom, under contemporary conditions, that a four-year education can adequately prepare a man for the higher reaches of professional work in engineering.

Science, in the broadest sense, gradually becomes a major, if not the major, theme which runs through all higher education. It will be increasingly difficult to hold scientific education within any particular professional groove. M.I.T., therefore, will take its place as contributing to the broad flow of intellectually trained people who will play their parts in all aspects of government, industry, and community life.

All of this has a profound importance for our admissions policy. It means that we are not looking for narrowly defined patterns of individuals who will fit neatly into specific professional slots. A school of medicine, of law, or even of business might more properly look for patterns of this kind; we do not. The wide spectrum of types of personality and points of view indicated above will continue to be sought after. Together with the common core of interest in mathematics and science, there must be an intellectual curiosity, breadth of interest, and above all, energy – physical and intellectual – which will carry a considerable proportion of our people beyond an average or mediocre level of achievement. The great protec-

The nightmare of every admissions officer is the young man who is rejected as a poor risk and who turns up 20 years later with a Nobel prize. But we do accept a large number of students whose exceptional potentialities can scarcely be perceived at age 18, and many of whom surprise us by eventual achievements of outstanding merit.

M.I.T. Photo

M.I.T. Photo

Mrs. Julius A. Stratton and President Stratton greet visitors in the Institute's annual Guidance Conference held at M.I.T. for secondary school teachers and administrators.

tion of any selective admissions process is diversity. We are, to be sure, quite certain to miss many able people in our efforts at selection; the nightmare of every admissions officer is the young man who is rejected as a poor risk and who turns up 20 years later with a Nobel prize. To offset this peril, however, we do accept a large number of students whose exceptional potentialities can scarcely be perceived at age 18, and many of whom will surprise us by eventual achievements of outstanding merit.

Broadening the "Interface of Contact"

The admissions process at M.I.T. is thus an operation of broad scope in the areas of educational guidance and public relations. We are in some kind of contact with something like 20,000 potential freshmen a year who either write to us, visit us, or see one of our school visitors or an Educational Council member. Each of these has an opportunity to consider M.I.T. as a possible place for his education, and it is from these that the entering class of 900 is drawn. Our problem of information and guidance involves not only this large number, but their parents, teachers, advisers, relatives, and friends. Since it is out of the question for so great a range of contacts to be carried on by a small staff in the Admissions Office, we broaden out our area of communication with the educational public in four ways:

First, there is the program of Institute publications. In addition to the general catalogue, which is used both internally and as a source of general information on a wide variety of fronts, we have an undergraduate catalogue designed specifically with the needs of the prospective freshmen in mind. In this we strive to avoid the dullness of the typical college bulletin and to convey, so far as is possible in words and photographs, a realistic idea of what student life for the undergraduate is like here at M.I.T., minimizing rules, timetables, and purely formal statements. There is also a basic leaflet about admissions, as well as a number of special leaflets on lesser-known aspects of the undergraduate program.

Second is the program of visiting schools which has been greatly augmented in the last few years. Each year, some 35 members of the Faculty and Administration spend a week or more visiting secondary schools in all parts of the United States. This involves a great deal of preliminary correspondence and scheduling, since no school is visited without an invitation from the principal and an actual appointment made in advance. The school visitors are predominantly younger members of the teaching Faculty, but include also members of the Admissions Office staff as well as other administrative officers. As one result of this program, we now have on our Faculty a group of nearly 200 younger men who have had some direct contact with high schools and their problems. As a result, they have a much more realistic grasp of the problems of the transition from secondary school to higher education than is usually found in college faculties. We see, at M.I.T., little of the "teacher's syndrome" – that wonderful, unconscious arrogance found among teachers at every educational level who are prone to assume as a matter of course that no student has had a really adequate preparation until he reaches the particular teacher in question.

The whole tone of these visits to schools is one of educational guidance and information. The schools realize that they have a formidable problem of guidance in conveying to a new crop of youngsters each year some appreciation of the values inherent in higher education. This is particularly difficult in the areas related to science, where so many misconceptions exist. As soon as the schools discovered that we conduct these visits as a broad-minded effort to give educational guidance, rather than as a selling or recruiting project, they welcomed us warmly. Some even utilize the visits of the M.I.T. representative as a normal, annual part of their regular educational guidance program.

Most members of the Educational Council know at first hand how the school visiting program works from having accompanied school visitors on their rounds. These joint visits are encouraged since they help both the visitor and the Alumnus. We normally visit about three schools a day, talking with a carefully preselected small group of students in a kind of informal guidance seminar. This is more useful than making speeches to large assemblies on the one hand, or than interviewing a few individuals intensively on the other. In a stimulating question-and-answer session, often attended by school guidance counselors as well, students feel they have made direct personal contact with an Institute representative, as indeed, we feel, they have.

Our third device for broadening our contact is the annual Guidance Conference. We hold annually here in Cambridge each fall, a conference on educational guidance to which we invite about 100 carefully selected guidance counselors from high and preparatory schools all over the United States. It is necessary partially to subsidize the travel expenses of this group in order to make it possible for them to come at all. Here also we try to avoid the propagandist and selling approach.

(*Continued on page 216*)

A Tooth for a Tooth

The old Biblical adage takes on new meaning as new plastics, high-speed drills, precision-casting methods, and improved techniques make dental procedures relatively comfortable

by FREDERIC W. NORDSIEK

SOME 30 per cent of the healing practitioners of this country are dedicated to caring for less than 1 per cent of the human body; yet they are waging a losing battle. The human teeth constitute less than 1 per cent of the body, whether gauged by bulk or weight. There are about 100,000 dentists in the United States who devote their time and skills to treating, repairing, extracting, and replacing teeth; and there are only about a quarter of a million physicians to minister to the rest of the human body.

Yet the dentists never catch up with their work — indeed, under present conditions, they never could. Take New York City, a community relatively privileged in having some 9,000 dentists to take care of the mouths of its 8,000,000 people. Each of these people may, according to authoritative local surveys, be expected to develop, on the average, a new tooth cavity each year. But, among them, New Yorkers right now have about 35,000,000 untreated tooth cavities. A total of some 40,000,000 hours in the dental chair would be needed to repair these defects at present existing, and it would take a dental task force at least three times as large as New York's currently existing one to accomplish such a gigantic repair job. Similarly precise knowledge of dental needs and facilities is not available for the country as a whole; but one authoritative estimate holds that, throughout the United States, not more than a quarter of the needed dental care is being provided.

Thus, although American private citizens pay dentists some one and a half billion dollars per year — a sixth of their total medical expenditures — and also through taxes and donations support much free dental care for underprivileged persons, the teeth of Americans, by and large, are in sad shape. For example, missing or bad teeth were the largest single cause of medical rejections among the first 2,000,000 men examined for service in World War II. Six or more upper teeth meeting six or more lower teeth were then deemed to be adequate equipment for coping with Army chow; not a very stringent standard considering that a full complement is 16 teeth in each jaw. But nearly 10 per cent of the draftees, from ages 18 to 35, did not have six pairs of teeth that met!

Animals and Early Man

As the human being has struggled upwards to the pinnacle of evolutionary development, he has left good teeth behind him. The lower vertebrates, the nonhuman mammals, ancient man, and even present-day primitive men still living in their original natural environments, by and large have sturdy teeth.

The human being, like the other mammals (but in contrast to the lower vertebrates) has a limited and definite number of teeth. The human dental equipment, together with that of some animals, is shown in Table I. Human deciduous teeth start to erupt at about the age of six months, and start to be replaced by the permanent teeth at the age of about seven years. By the time a human being is some 11 years old, he usually has all of his permanent teeth except the third molars (wisdom teeth) that may or may not appear some time between the 15th and 21st year of life. Most mammals, like man, have two sets of teeth in the course of life, although bats and guinea pigs shed their deciduous teeth before they are born!

As Table I indicates, the lower vertebrates (for example, sharks) have an indefinite number of undifferentiated teeth, and these creatures usually have relatively large numbers of teeth. Indeed a reduction

Harold M. Lambert

Now that dental procedures have become relatively comfortable, surely everyone can afford the services of a competent dentist and will want to do so regularly.

TABLE I

The Teeth of Man and Various Animals

Species	*Jaw*	*Left Side*				*Right Side*				*Total*
		Molars	*Premolars*	*Canines*	*Incisors*	*Incisors*	*Canines*	*Premolars*	*Molars*	
Man— Deciduous teeth	Upper Lower	2 2	0 0	1 1	2 2	2 2	1 1	0 0	2 2	20
Man— Permanent teeth	Upper Lower	2-3 2-3	2 2	1 1	2 2	2 2	1 1	2 2	2-3 2-3	28-32
Old World Monkeys	Upper Lower	3 3	2 2	1 1	2 2	2 2	1 1	2 2	3 3	32
New World Monkeys	Upper Lower	3 3	3 3	1 1	2 2	2 2	1 1	3 3	3 3	36
Horse	Upper Lower	3 3	3 3	1* 1	3 3	3 3	1* 1	3 3	3 3	40
Bear	Upper Lower	2 3	4 4	1 1	3 3	3 3	1 1	4 4	2 3	42
Pig	Upper Lower	3 3	4 4	1 1	3 3	3 3	1 1	4 4	3 3	44
Opossum	Upper Lower	0 0	7 7	1 1	5 4	5 4	1 1	7 7	0 0	50
Lower Vertebrates	Upper Lower	Indefinite Number of Undifferentiated Teeth								

* The canine teeth of the horse are small and nonfunctional; the gap thus created is occupied by the metal bit used to control domesticated horses. [Nordsiek, Frederic W. "Horse Power," *The Technology Review*, 60:307 (April, 1958).]

in number of teeth is considered to mark evolutionary advance, associated with terrestrial life, less bulky food, more chewing, shorter jaws, and stronger muscles of mastication. This trend is currently operating in human teeth. Thus the wisdom teeth, although invariably present and well developed in primitive human beings such as the Australian aborigines, do not always develop in more highly evolved, more civilized man. For example, the present writer (a highly evolved type) never did have lower wisdom teeth and, by x-ray evidence, does not even have vestigial evidences of these teeth in unerupted form.

Modern human teeth really have only two mechanical functions in connection with eating — shearing and grinding. The incisor teeth in the front of the mouth act like scissors, and thus make possible the taking of dainty bites from comestibles such as sandwiches. Tidbits like these, as well as portions of food forked or spooned into the mouth, are ground to an easily swallowed state by the premolars and molars which are located towards the rear of the oral cavity. The four canine teeth surviving in the human mouth are vestiges of tusks or tearing teeth that serve carnivorous animals for fighting, as well as for eating; modern human canine teeth have some shearing action but are inefficient in this regard because of their tusk-like shape.

It is noteworthy that in ancient primitive man, who was invariably prognathous, the incisors did not have a shearing action, but came directly together face to face and wore into flat grinding surfaces. These ancient peoples had no need to cope decorously with food items such as sandwiches, but used all of their front teeth to crush and tear foods, just as predatory carnivorous animals, like lions, do today.

Tooth and Claw

Wild animals employ their teeth and their claws for weapons and for tools, as well as using their teeth for eating purposes. Animals' teeth withstand such vigorous usage because they are sturdy, and also in some species because they are regularly renewed. Many lower vertebrates, for example the sharks, are "polyphyodont"; that is to say, new sets of teeth continue to grow into place throughout their lives. Thus in sharks, there is a line of teeth in active service at the edge of the jaws. Behind these are successive rows of progressively smaller spare teeth, that steadily grow and advance forward into the line of duty as their forerunners are worn, broken, or shed.

In other beasts, such as rodents and horses, there is only one adult set of teeth, but individual teeth continue to grow up afresh from the roots as fast as they wear away at the crowns. To be sure, in rodents this usually fortunate endowment can by accident have bizarre and fatal consequences. The two upper incisor teeth of these creatures wear against the two lowers, and thus keep in suitable balance. If the beast accidentally breaks an incisor, the opposing tooth has no check upon its size; it keeps growing until the mouth cannot be closed and starvation ensues.

As we have seen, the human being, like all mammals, is "diphyodont," meaning that in the course of a lifetime he is privileged to enjoy only two sets of teeth. Is it not ironical that the human teeth, which man needs so very much – to eat, to talk, and for cosmetic reasons – do not have the ability to replace or regenerate themselves, as do the teeth of some other vertebrates; whereas human claws (fingernails and toenails) which nowadays find only limited and dispensable use (such as for picking up coins, for opening jackknives, or for scratching itches) continue to regenerate as vigorously as did the constantly used claws of our evolutionary forebears, and as do those of present-day animals. Hence a paradox: On the one hand, we must pamper, patch, and prop our valuable but weak and irreplaceable teeth; on the other hand, we must waste innumerable hours to cut and file our useless fingernails and toenails, or else spend many dollars to delegate nail trimming to manicurists and podiatrists. Also the vigorous regenerative powers of human nails leads to that uniquely human ailment, ingrown toenails. If only human teeth could regenerate as vigorously and insistently as do human nails!

Why So Weak?

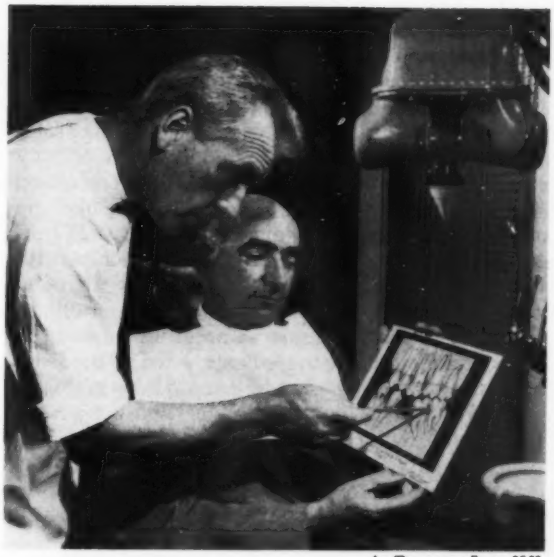
Why are human teeth so frail? A rephrasing of this question will point up the difficulty in answering it. Why are most human teeth so frail, whereas some others are so very sturdy? There are as many imponderables as ponderables in the picture of tooth decay. Human teeth, even those of siblings who have been exposed to apparently identical environments, vary widely in chemical composition, physical structure, and durability. Heredity is very likely a factor in dental health; but in any species as mixed up genetically as is the human being, hereditary factors are always difficult, sometimes virtually impossible, to assess.

Diet, especially in early life, very likely plays a role in dental welfare. The element fluorine, which as we shall see presently is today's bright hope in reducing tooth decay, may be regarded as a dietary factor; although it is consumed more in drinking water than in foods. Certainly diets low in calcium, in phosphorus, in vitamins A, C, and D, or in protein, are not conducive to dental health, any more than they are conducive to general health.

Malocclusion, severe enough to cause mechanical stresses or excessive abrasion on particular teeth, poses a definite dental threat. Similarly, habitual gritting, grinding, or clenching of the teeth, which in some people may occur during sleep as well as during waking hours, may cause considerable tooth damage. Still another source of mechanical injury to teeth is the widespread, if infantile, human need for oral gratification, fulfilled by placing in the mouth (often between the teeth) hard objects such as cigarette holders or pipestems or, in nonsmokers, by chewing articles such as pencils or paper clips.

How Teeth Decay

Thus any person's teeth may either be susceptible to decay or else resistant to decay, depending upon the nature of his teeth and the chemical, biological, and mechanical conditions existing in his mouth.



A. Devaney, Inc., N.Y.

Today's dentist, that remarkable blend of healer and skilled mechanic, can do wonders with his modern armamentarium.

These factors, in turn, may be attributed to ponderable and imponderable genetic, developmental, and environmental causes. It is clear, however, that the immediate local effect causing most dental decay is a combined bacterial and chemical action in the mouth. Mechanical abuse of teeth is, at most, a contributory cause; injury by thermal shock, as by the alternating ingestion of hot and cold foods or beverages, is suspected but not clearly indicted.*

Hence a logical question is: "Why not prevent local bacterial-chemical action on the teeth?" This is a most desirable objective, but to date an unattainable one. The mouth cavity cannot be kept free of microorganisms any more than can other parts of the human digestive tract. An antiseptic potent enough to significantly destroy mouth bacteria would also seriously injure mouth tissues. Even if the mouth could be sterilized, it would promptly be reoccupied by microorganisms taken in with air and food.

To some degree, microorganisms in the human mouth may attack the tooth structure directly, but mainly do their mischief by generating acids while thriving upon substrates provided by food residues. Why not, then, eliminate the food residues? Such elimination is attempted and in some measure achieved by the customary brushing of the teeth; but to be at all effective, brushing would have to be done immediately after ingesting foods or beverages. Even then, brushing is only partly effective, because food residues lodge securely in inaccessible crevices and otherwise resist removal. Laboratory animals ordinarily subject to dental caries may be kept caries-free by feeding them through stomach tubes so that their feed does not come in contact with their teeth. Anyone wishing to adopt, for his own use, this method for preventing tooth decay may find the necessary equipment in most well-stocked drugstores.

The latter comment was intended to be facetious, but drugstores and other retail outlets do conduct a

* "Blow Hot, Blow Cold," *The Technology Review*, 57: 469 (July, 1955).

thriving business in supplies that purport to combat tooth decay, namely toothbrushes and dentifrices. Here our humor must turn from facetious irony to low comedy, for dentifrices and toothbrushes have provided a field day for the fatuousities of those great American institutions, popular advertising and sales promotion. As any dentifrice can do its work only by providing a suitable soap or other detergent mixed with a mild abrasive, and as toothbrushes, like any sort of brush† can be nothing more or less than suitable bristles set in a convenient handle, competitive claims for these products are of necessity about as nebulous and inane as those made for cigarettes.

Dentifrices have become as prone as gasoline to claims of added magic ingredients, often of unidentified nature and designated by numerals or gibberish names. Flavor is a big selling point, and even color. One recently launched toothpaste emerges from its collapsible tube in gay stripes of red and white! Perhaps the color approach represents a trend, because a toothbrush having bristles of two different colors has recently reached the market. Other features of problematical significance that toothbrush makers (or more likely their advertising agents) have brought forward include special arrangements of the bristle tufts, use of a succession of novel synthetic fibers for bristles, various shapes of handles, and bristle heads attached to handles at bizarre angles. Gadget appeal has recently been applied to dentifrices as well. One may now obviate the fatiguing necessity of squeezing a collapsible tube by adopting a newly introduced dentifrice that is packed in a push-button dispenser.

Tooth Composition

Despite their frailties, teeth are nevertheless the hardest and densest tissues of the human body. Their structure and composition are variable and complex; included are organic, as well as inorganic, substances. Suffice it to point out here, however, that the enamel, the hard outer layer of the teeth, is principally calcium phosphate and fluoride, with some calcium carbonate and magnesium phosphate, traces of other salts, plus about 4 per cent organic matter.

Calcium, phosphorus, magnesium, and fluorine for tooth construction must be taken into the body from the outside, in food or drink. It is virtually impossible to consume diets deficient in phosphorus or magnesium. Calcium deficiencies are not uncommon, but may easily be avoided by careful inclusion of protective foods, such as milk and milk products. It is fluorine, the remaining element, that has turned out to be a key to improvement of dental health. To be sure, fluorine compounds in *substantial* amounts are toxic; sodium fluoride, for example, is a widely used cockroach poison. But in *trace* amounts, fluorides have proved to be a governing and fortunately a controllable favorable factor in dental welfare. How this fact was established and brought to practical application is an absorbing tale of the pursuit of scientific truth.

Colorado Stain

In 1902, Frederick S. McKay, then a neophyte dentist practicing in Colorado Springs, Colo., became interested in a locally prevalent brown discoloration of the teeth, popularly called "Colorado stain" and known to dentists as "mottled enamel." McKay kept careful records of tooth conditions he observed in local patients, collected epidemiological data on the occurrence of mottled enamel in his and other communities, and enlisted the interest of other workers in pursuing parallel and divergent pathways of investigation of the topic. As McKay's records on individuals having mottled enamel accumulated, it soon became clear to him that these people had much fewer dental cavities than the general population.

By 1916, the studies by McKay and his collaborators had reached the point of suggesting that something in the drinking water of communities like Colorado Springs was the causative agent of mottled enamel. But not until 15 years later were chemical analytical methods of sufficient precision (spectrophotometry) developed to quantify the very small concentrations of fluorine found in drinking water, and to indict (or, as it later turned out, to acclaim) fluorine as the active agent. Around 1931, it was established that all water supplies tested contained trace amounts of fluorine, ranging from a small fraction of a part per million to some 18 parts per million. The mottled enamel communities were those with relatively high fluorine water supplies.

Thereupon the first fruits of this research were plucked; alternative water sources were developed for the mottled enamel communities, and soon "Colorado stain" disappeared. But this was a purely cosmetic gain, for mottled teeth, although unsightly, were by and large exceptionally strong teeth.

By now further study of the data accumulated through the decades, while mottled enamel was being studied, yielded findings that were to benefit the whole country – indeed ultimately the entire civilized world – not just the relatively few residents of the old "mottled enamel" areas.

(Continued on page 204)

TABLE II

Each year since fluoride adjustment of water supplies was launched in 1945, more and more Americans have received the benefit of this aid to better teeth.

Year	*Fluoridation status at end of each year*		
	Number of communities	*Number of water supply systems*	*Population*
1945	6	3	231,920
1946	12	8	332,467
1947	16	11	458,748
1948	24	13	581,683
1949	46	29	1,062,779
1950	95	62	1,578,578
1951	329	171	4,948,259
1952	709	353	13,552,501
1953	949	482	17,080,930
1954	1,128	571	21,208,304
1955	1,274	667	24,775,698
1956	1,487	759	31,416,112
1957	1,631	870	33,294,899

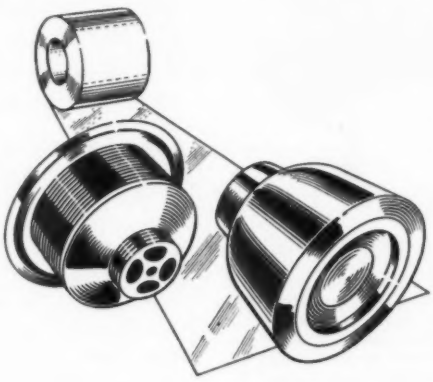
From: *Public Health Reports*, July, 1958, page 465

† "No Brush-off," *The Technology Review*, 53: 465 (July, 1951).

BUSINESS IN MOTION

To our Colleagues in American Business . . .

Although miles apart in their functions the door knob and sink strainer shown below have one thing in common. Both are made from Revere Brass Strip. Revere Leaded Brass Strip was used to make the sink strainer because of the ease with which large diameter threads are machined, the excellent surface it develops for chrome plating, the inherent corrosion resistance of brass and its drawing characteristics (strainer had to be drawn from .065" gauge x 7" strip to a 2½" depth).



The Revere Brass Strip used by the manufacturer of seamless, one-piece door knobs possessed still other characteristics that made it the most desirable for that specific purpose. Because of the unique procedure by which these knobs are made the brass has to be able to stand up under some mighty rugged going. Further, the brass strip has to be of uniform gauge and be without any sign of fracture or crimping when drawn, as well as have consistently correct grain structure to insure a smooth, flaw-free surface on the finished knobs without extensive finishing and polishing operations.

These are but two of the literally thousands of ways Revere Brass Strip makes it possible for manufacturers to offer *their* customers a superior product at the lowest possible cost.

The combination of unusual properties makes Revere Brass Strip, in various anneals and tempers, equally suited to stamping and spinning. Manufacturers have found that the high ductility and malleability of various Revere Brass Alloys effect savings in time and cost because deeper draws in one operation are possible. And, because of the low, work-hardening rate, a combination of forming processes is frequently possible in making intricate shapes without the need for intermediate annealing. Should annealing be required the temperatures used are low (usually not over 1100°F.) which means lower fuel cost.

Revere Brass Strip not only permits deep draws, but fast draw speeds as well, which is particularly desirable for repetition press work or other operations where parts are produced in large quantities. This means relatively low power consumption.

Revere Brass Strip does not foul dies quickly, requiring only a minimum of die re-dressing. And one of its most desirable features is that it plates well and polishes easily, requiring only a minimum of finishing.

Revere Brass Strip in its various alloys is still another example of how, by fitting the metal to the job, it is possible to produce superior products at the lowest possible cost.

Practically every industry you can name is able to cite similar instances. So we suggest that no matter what your suppliers ship you, it would be a good idea to take them into your confidence and see if you cannot make a better product at lower costs by specifying exactly the *right* materials.

REVERE COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

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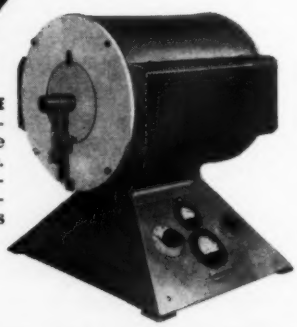


HEVI-DUTY ELECTRIC COMPANY

MILWAUKEE 1, WISCONSIN

Harold E. Koch, '22, *President*
Elton E. Staples, '26, *Vice President*
Chester Meyer, '36, *Assistant Secretary*

TOOTH FOR A TOOTH

(Continued from page 202)

Fluorine Reduces Decay

The dental records of the people whose tooth conditions had been compared with the fluorine level of their drinking water pointed clearly to a "golden mean" of about one part per million of fluorine. At this level, tooth decay did occur but was relatively rare. In communities where the water contained much less than one part per million of fluoride, dental caries was widespread. Then, as already stated, at high fluoride levels of 15 parts per million or so, unsightly mottled teeth occurred.

These findings led to the obvious, inexpensive, and entirely practical procedure of adjusting the fluoride content of municipal water supplies by adding controlled amounts of fluorine salts. When first launched, fluoridation of water supplies became a focus of opposition, largely of an emotionally polemical nature, just as had smallpox vaccination, water chlorination, and vitamin enrichment of bread and flour when they were first introduced. Nevertheless, scientifically established fact and the general welfare are, as ever, prevailing in the course of time. Controlled fluoridation of water supplies was first carried out at Grand Rapids, Mich., on January 25, 1945. Table II shows how more and more Americans have come to enjoy the benefits of water fluoridation – by the end of 1957 totaling 33,294,899 people dwelling in 1,631 cities and towns. Now, most large U.S. cities fluoridate their water; the rest are expected to do so soon. Fluoridation costs less than $0.20 per resident per year.

The full value of water fluoridation will make itself felt in future years. Fluoridation is most effective in young children less than eight years of age, and it will be a while before the youngsters now enjoying this advantage become adults possessing sounder teeth than their forebears. Let it be emphasized that fluoridation, like any biological measure, is not 100 per cent effective. It does, however, accomplish a reduction of well over 50 per cent in dental decay.

Dental Skills

Meantime the training of an increasing number of dentists and rapid advances in dentistry techniques bode well for the care of already existing dental defects. Today's dentist, that remarkable blend of healer and skilled mechanic, can do wonders with his modern armamentarium. Drilling, most troublesome of the dental procedures, has been made relatively innocuous by a series of mechanical advances, culminating lately in the introduction of ultra-high-speed drills that virtually eliminate perceptible vibration.‡ Less than a decade ago, the speed of 6,500 revolutions per minute was standard for dental drills; now speeds of up to 250,000 r.p.m. are used. Ingenious air- and water-spray arrangements take care of the increased heat generated by the high speeds. Of course these tools cut faster, thus conserving substantial amounts of the dentist's precious time as well as reducing the duration of discomfort for the patient.

(Concluded on page 206)

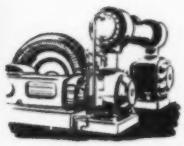
‡ "Open Wider Please," *The Technology Review*, **57**: 280 (April, 1955).

YOUR LEADERSHIP CAREER

with INGERSOLL-RAND

Testing a double-case, high-pressure, boiler-feed pump in Ingersoll-Rand's hydraulic laboratory. Pumps of this type feed hot water into steam boilers at pressures up to 6500 psi.

also means LEADERSHIP in



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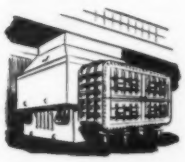
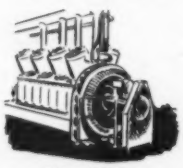


Steam Condensers



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TOOTH FOR A TOOTH

(*Concluded from page 204*)

Pain during dental operations is controlled by skilled local anesthesia or by gas analgesia. In the latter procedure, a gas inhalation anesthetic is administered at a low rate. The patient is lulled to the point of being unable to experience pain but is sufficiently conscious to sit up, expectorate when directed, and otherwise co-operate.

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Practical Action

The practical courses of action toward good teeth this discussion has suggested are perhaps more effectively applicable to the reader's children than to the reader himself. The eating of a well-rounded diet, including liberal amounts of the vitamin-, mineral-, and protein-rich protective foods, throughout life is a commendable practice for general well-being, not just for dental welfare. Now that dental procedures have become relatively comfortable, surely everyone who can afford the services of a competent dentist will want to do so regularly. Anyone can find the time and energy to brush his teeth, employing for the purpose whatever dentifrice suits his aesthetic and gustatory preferences, and whatever make of toothbrush provides such gadget appeal as pleases him. Virtually universal fluoridation of water supplies now appears to be an inevitable eventuality, but if the enlightened reader comes against controversy on the subject, he will do well to throw his weight in favor of fluoridation. As to the many imponderables in dental decay, there is obviously little one can do. Take the question of possible hereditary factors in dental well-being. It has been stated that those who wish to live long should select long-lived ancestors; similarly, those who desire good teeth should make sure they have forebears thus endowed. But then everyone wants good teeth for, as Cervantes wrote three and a half centuries ago in *Don Quixote:* "Every tooth in a man's head is more valuable to him than a diamond."

§ "Defy the Tooth of Time," *The Technology Review*, **55**: 415 (June, 1953).

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THE CHALLENGE

(Continued from page 194)

ropean ancestors encountered the cultivated crops of the American Indians. Indeed, you can say that the peoples who preceded the Mayans, and those of the Rio Grande Valley, made an enormous step forward when, in America, they domesticated crops that were unknown to the rest of the world. They domesticated maize, which cannot reproduce itself without human help, and this was a tremendous step forward. Indeed, probably there has been no correspondingly big advance in food production since those early prehistoric times, even when we consider crop rotation and farm mechanization.

True, through scientific effort we have improved considerably the vigor and yield of most crops and we now handle and process them much better than in the past. We preserve foods better and, indeed, we now have respect for vitamins. Nevertheless, we still plant essentially the same crops as did our ancestors, and we still eat either a part of plants or feed the plants to animals and then eat the flesh of the animals. This is a very unpleasant description of a good steak, but I am afraid it is the truth.

It seems certain that world problems of food production will inevitably be mitigated by knowledge resulting from intensified studies in the life sciences. I believe we can even dare to hope that such knowledge will give us clues to new kinds of food which can be produced in some other medium than through the growing of green plants in the soil. Perhaps some other form of energy can be substituted for sunlight; possibly other nutrients can be substituted for those that either exist naturally or are artificially put into the soil. Therefore, we should encourage the presently growing interest in the life sciences.

Energy Problems

What about over-all energy requirements? Even for a much larger world population and a substantially increased per capita use of energy, existing fuels, including solar energy (if we may call that a fuel) and uranium, will satisfy our needs for a long time to come, with one exception. At the present time, there seems to be no way to replace the fossil fuels – the oil, natural gas, and coal – for operating mobile power plants on which we depend so much. If you have driven in New York or Los Angeles

(Continued on page 210)

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THE CHALLENGE

(Continued from page 208)

lately, you will appreciate how much we depend on automobiles; and trucks, tractors, and airplanes are also essential parts of our present way of doing things. Except for the biggest of these vehicles, it does not seem to me that nuclear reactors and the use of uranium as fuel are likely to be substitutes for the fossil fuels. In a world competing for fuel, we are going to be in real trouble by the next century, unless we can develop some substitute for fossil fuel for vehicles (in particular the smaller ones); or unless radically different mobile power plants are devised.

Another problem is raw materials. You remember the Paley report of some years ago which stressed the problem of raw materials – the materials which our industry is already using at an enormous rate. As we go forward with industrialization of the underdeveloped countries, inevitably the rate of use of the world's natural raw materials will again be increased by large factors, and inevitably some natural resources must be expected to become depleted. For example, our present-day supply of iron ore cannot last forever.

We must meet the challenge of materials. One of the last frontiers of physical science is the study of the nature of solid state materials. Solid state physics is one of the last frontiers because it is such a difficult subject. But we must not neglect it because it is difficult. We know that mass-produced metals are much weaker than certain samples of the same metals produced by special processes in the laboratory. If we can discover exactly why this is true, we will be in a position to develop new mass-production techniques for much stronger metals and thus be able to use very much less metal for each application. Less metal for each job will mean more effective use of the world's resources, both for us and for other countries. Therefore, for our welfare as well as for improving relations with other peoples, it is important to emphasize the study of the mechanical – and other – properties of materials in the solid state.

Perhaps enough has been said to make the point. We need science and technology specifically for problems that are related to conservation of the world's raw materials. We need science and technology to make a big step forward in the production and distribution of food. We need science and technology to find a new way to propel motor vehicles, as fossil fuels become more scarce and more expensive. We need science and technology to help maintain our military muscles. Science and technology are necessary not only to deter big war – the war that must never happen – but also to prosecute little wars – that are almost certain to happen if we understand history correctly.

These are my examples, and only *my* examples, of our need for emphasis on science and technology. Others would have a different set of items. No claim is made that this list is complete by any means. But science and technology do not stand alone; truly peaceful coexistence also requires human under-

(Continued on page 212)

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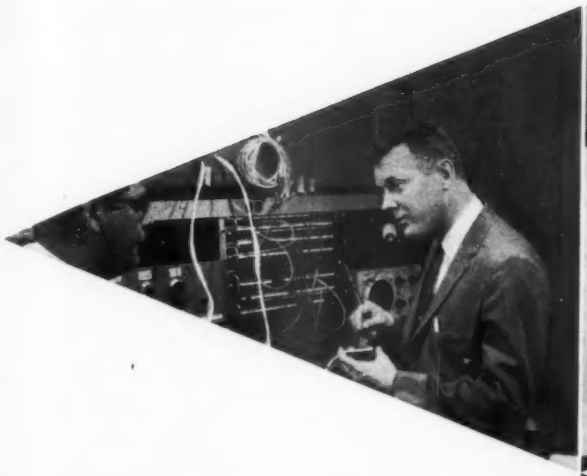
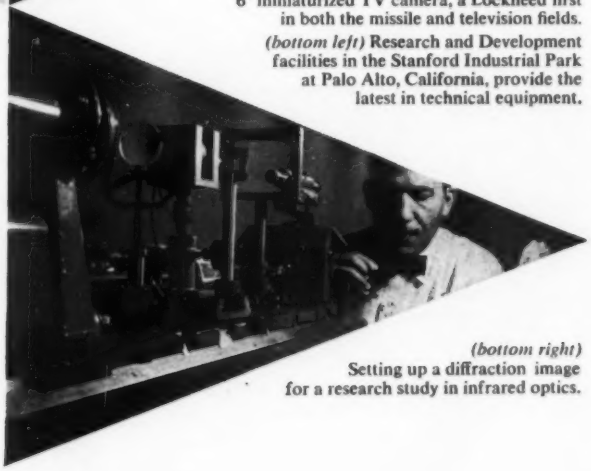


(top left) Transistorizing missile flight control systems by Lockheed scientists has meant significant reductions in weight and space requirements.

(top right) Monitoring new air-borne 6" miniaturized TV camera, a Lockheed first in both the missile and television fields.

(bottom left) Research and Development facilities in the Stanford Industrial Park at Palo Alto, California, provide the latest in technical equipment.



(bottom right) Setting up a diffraction image for a research study in infrared optics.

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THE CHALLENGE

(Continued from page 210)

standing. Perhaps you have already noticed that I could not help referring to nontechnical matters even in a discussion of technical problems. I mentioned the need for a military organization to develop, through actual long-distance exercises, the tactics, doctrine, capability, and equipment for limited war. I mentioned the political and diplomatic activity which must accompany military action in limited war. I mentioned the widespread misunderstanding of our culture and, in the opinion of others, the peculiar reversal of roles that exists concerning us and the Russians.

At the present time, even the purest of scientists seems to be at least *interested* in how scientific knowledge can be applied to the world's problems. Most of the pure scientists I know are more than interested; they actively encourage or push work on applications of science. They are all keenly aware that the world's problems always involve people. It is important that we keep learning about man himself – man and the way he organizes to do things.

In this connection, Professor Peter F. Drucker, who likes to observe our business society from the detachment of the university campus, has made an interesting observation. He recognizes that America is famed for having developed mass production and that our success in mass production is usually considered to be an engineering achievement involving such concepts as interchangeable parts in mechanical assembly lines. But Peter Drucker thinks that our basic achievement in mass production actually has been an organizational, rather than an engineering, achievement. Our large business organizations have made possible bigger accomplishments and have provided real economic gains. In the same way, large scientific and engineering organizations have been found capable of coping with very large and complex technical problems.

Probably those who have worked in them would have two comments to make regarding large organizations. First, large organizations cannot claim to have been perfected; they still have many problems to solve. Second, despite these problems, the accomplishments of large organizations actually justify Professor Drucker's enthusiasm. Our industrial economy provides evidence of the truth of this last comment.

(Concluded on page 214)

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THE CHALLENGE

(Concluded from page 212)

Moreover, it is now well known how successfully scientific creation and engineering excellence can be combined and developed in a large organization. There are examples of this in industry, in Atomic Energy Commission laboratories, and at such institutions as M.I.T.

Laboratory for Human Sciences

Perhaps it would be worth while to experiment with a big laboratory to study and evaluate methods for dealing with some of our long-range human and technical problems. We have here in New Mexico, alone, an organized effort involving about 20,000 civilian and military people who are primarily engaged in the development of military applications of nuclear explosives. Yet nowhere in this country is there a corresponding organized effort on such enormously important problems as food production and distribution, or the impact of industrialization on the peoples of underdeveloped areas.

It is true that we have no assurance that such an attack on long-range peacetime problems would really work, but it seems to me that this matter should be given the most serious consideration. Our challenge is to use our technical resources so that we remain strong not only as a military power, but also as a peaceful civilization.

I believe we have organized the effort to keep us from being involved in the big war. Now is the time to do some positive thinking and take some positive action about limited wars. Both these aspects of our military protection depend heavily on science and technology. They also depend on people and how they are organized to live and work. All of this is also true of the long-range peacetime problems of our society. Our preoccupation with military problems must not prevent us from devoting some of our best resources of people and organizational ideas to problems of peace. Perhaps we can learn how to enlarge and make more effective our attack on problems of peaceful living, by borrowing from our industrial and academic experience in building large creative organizations. This experience with large creative organizations is an important aspect of the over-all strength of our society. It is one of the assets we are using to avoid a military path to extinction. It could well be an important asset in avoiding the Mayan path to extinction.

TREND OF AFFAIRS

(Concluded from page 190)

University of California; and Clyde Kluckholn and Henry A· Murray of Harvard.

Discussions of these essays were written by: Dr. Riesman; David M. Potter of Yale University; Richard M. Bissell, Washington economist; Richard Hofstadter of Columbia University; and Elting E. Morison, Professor of Industrial History at M.I.T., who also edited the book.

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COLLEGE ADMISSIONS — I

(*Continued from page 198*)

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Partly because these visitors have so many interests in common, and partly because they see each other so seldom, they find these conferences of great help and interest, and go away full of enthusiasm. There seems to be no substitute for getting people actually here and into the M.I.T. atmosphere for a couple of days in order to convey to them what the Institute is really trying to do. One feature of the program is to have M.I.T. undergraduates from each of the secondary schools act as hosts at lunch for the counselors from their respective schools. In this way, the important objective is met of having the school representative get a first-hand impression of how his students are getting along without the information going through any M.I.T. intermediary.

(*Concluded on page 218*)

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COLLEGE ADMISSIONS — I

(Concluded from page 216)

The fourth and most important of the major agencies involved in broadening the admissions process is the Educational Council. This body of over 700 Alumni, many of them very experienced and all enthusiastic and loyal, has made a contribution of incalculable value to M.I.T. and to the broad problem of educational guidance in the United States. There is no substitute for an informed group at the grass roots who are always available locally and in contact with the individual schools. The 1,200 high schools which are in direct touch, each with a member of the Council specifically assigned to it, have had good reason to appreciate the splendid work carried on by these men.

In the Council's work, as in the visiting program, the schools are reassured by the educational guidance approach and by the absence of recruiting and competitive tactics. It is a valuable privilege for a student at a distance to be able to talk to someone who has actually passed through the M.I.T. educational process and can convey to him at first hand some sense of what this is about. It is likewise of the greatest help to the Admissions Office to have the comments of an Alumnus, in whose judgment we have confidence, about a student on whom we have otherwise only paper evidence.

The Educational Council has, to a considerable extent, set a standard and an example for similar efforts in other institutions. Its chief merit lies in its genuine educational approach, in contrast to the kind of shortsighted recruiting efforts which have so often aroused hostility in the high schools. While we are very anxious that a candidate should have a complete knowledge of M.I.T., so far as this is possible, so that he can make an intelligent selection, we feel that a candidate who comes here solely because of heavy selling pressure is seldom a good risk. We want him to make his own decision with full knowledge of the alternatives open to him.

Part II of Professor Thresher's article will appear in the March issue of The Review. In his concluding article, Professor Thresher will discuss methods used in the selection of students, danger signs to be heeded, and some of the current practices and problems in the field of college admissions. – Ed.

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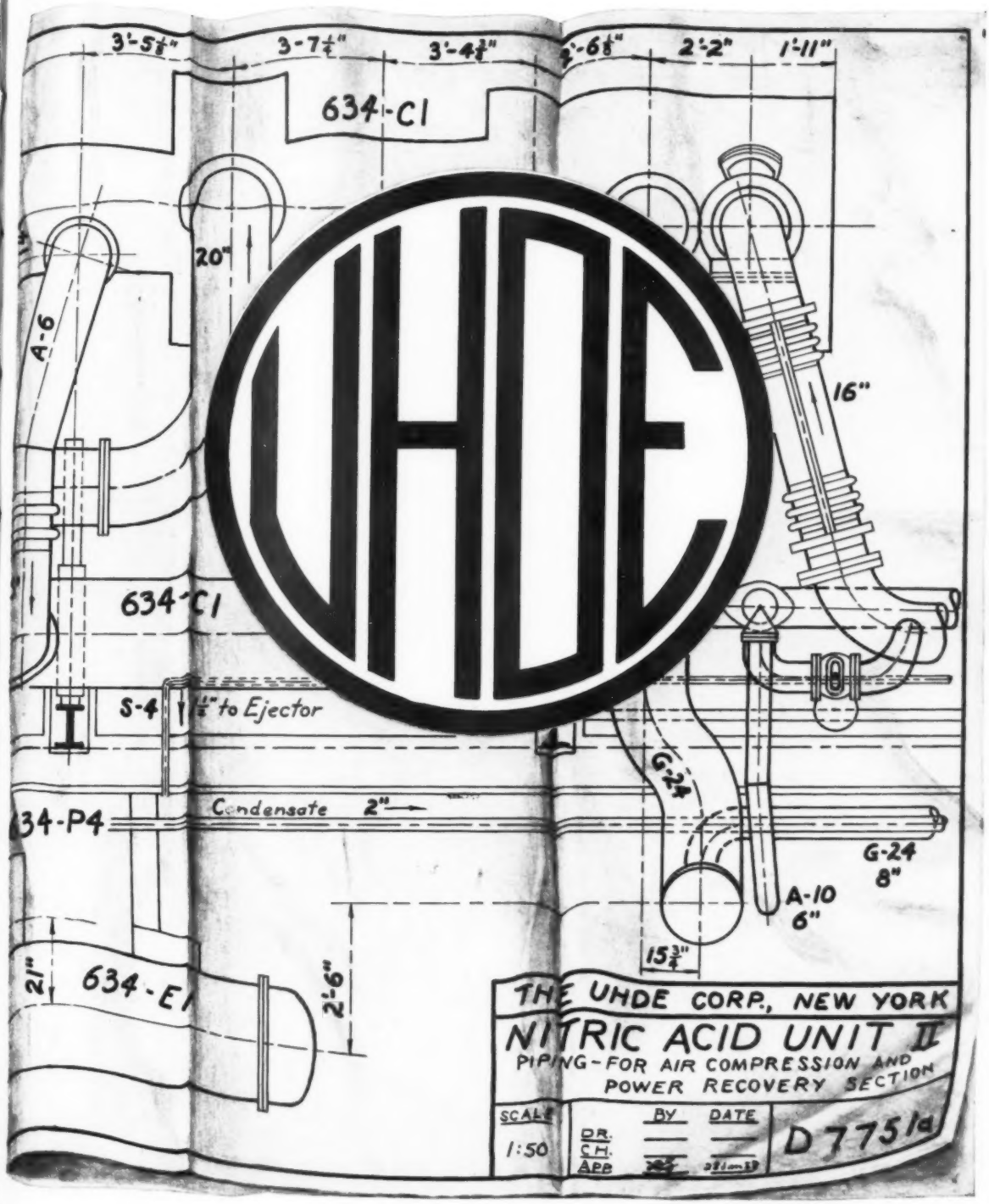

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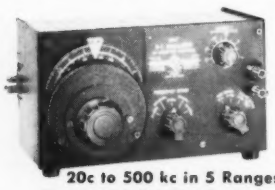

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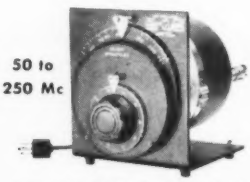

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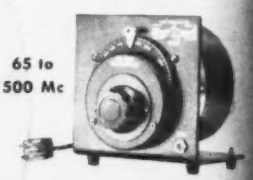

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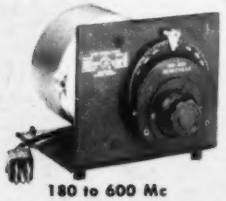

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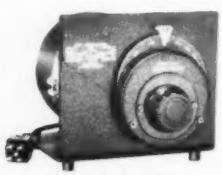

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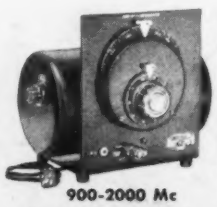

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